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Seaplane view of U. S. Naval Academy, Annapolis, Md.

Activities

of the

Bureau of Yards and Docks

Navy Department

World War
1917 - 1918

WASHINGTON
GOVERNMENT PRINTING OFFICE
1921

NAVY DEPARTMENT,
Washington, February 10, 1921.

MY DEAR ADMIRAL: It was through the efforts of the Bureau of Yards and Docks that the facilities of the Navy ashore were extended so successfully to meet the increased demands brought upon them during the World War.

It appears desirable, therefore, that the work of the bureau, in providing the necessary training camps, air stations, storage facilities, hospitals, radio towers, ship-repair facilities and dry docks, etc., in this country and abroad, should be made a matter of record. Kindly prepare such a description, which will, I am sure, be of value to the Navy and to others interested in the Navy.

Very sincerely, yours,

JOSEPHUS DANIELS,
Secretary of the Navy.

Rear Admiral C. W. PARKS (C. E. C.), U. S. N.,
Chief of Bureau of Yards and Docks,
Navy Department, Washington, D. C.

NAVY DEPARTMENT, BUREAU OF YARDS AND DOCKS,
Washington, D. C., February 28, 1921.

MY DEAR MR. SECRETARY: In accordance with your instructions of the 10th, I have caused to be prepared the accompanying series of chapters of an historical nature, dealing mainly with the activities of this bureau during the World War. In the nature of the case it has been considered advisable to outline the status of most of the Navy's shore facilities prior to the declaration of war by the United States; and in several instances the scope of the war program as undertaken during 1917 and 1918 made it impracticable arbitrarily to terminate the narrative with the date of the armistice. Nevertheless, the account as it now stands represents in the broader sense of the term a careful record of war activities, limited, of course, by the exigencies of space in a compilation of this kind.

It is fitting at this time that I should make due acknowledgement of the enthusiastic assistance rendered in the preparation of this document, in the midst of their regular duties, by officers of the Civil Engineer Corps and bureau employees having charge of war projects either in the office or in the field. Contributions were received from officers now on bureau duty, as follows:

Naval Ordnance Plant, South Charleston, W. Va., by Capt. R. E. Bakenhus (C. E. C.), U. S. N., assistant chief of the bureau.

Housing for the Navy, and Shipyard and Industrial Plant Extensions, by Rear Admiral H. H. Rousseau (C. E. C.), U. S. N.

Public Works Organization and Station Development at Great Lakes, 1918, and Construction of the Pearl Harbor Dry Dock, by Commander Geo. A. McKay (C. E. C.), U. S. N.

The Lafayette Radio Station, Croix d'Hins, France, by Commander F. H. Cooke (C. E. C.), U. S. N.

Radio Stations, Marine Corps Projects, and Fuel Oil Storage, by Commander E. C. Sherman (C. E. C.), U. S. N. R. F.

Naval Academy Extensions and Emergency Hospital Construction, by Commander F. W. Southworth (C. E. C.), U. S. N. R. F.

Dry Docks, by Lieut. Commander H. D. Rouzer (C. E. C.), U. S. N. R. F.

Aviation Stations, by Lieut. K. B. Bragg (C. E. C.), U. S. N.

United States Helium-Production Plant, and Work at Ordnance Stations, by Lieut. Willard A. Pollard (C. E. C.), U. S. N.

Contributions from officers in the field were the following:

Yard Development, Housing, Water Supply, Shipbuilding Dock, and Training Camp, Puget Sound, and Training Camp at Seattle, by Capt. L. E. Gregory (C. E. C.), U. S. N.

- **Expansion of the Naval Training Station, Great Lakes, 1917, by Commander Walter H. Allen (C. E. C.), U. S. N.**
- **Air Stations Abroad, General Discussion, by Commander E. H. Brownell (C. E. C.), U. S. N., and Commander A. W. K. Billings (C. E. C.), U. S. N. R. F. (inactive list).**
- **Corps Activities in Haiti, by Commander E. R. Gayler (C. E. C.), U. S. N.**
- **Corps Activities in Santo Domingo, separate contributions by Lieut. Commanders Ralph Whitman and R. M. Warfield (C. E. C.), U. S. N.**
- **Corps Activities in the Virgin Islands, by Lieut. Commander Gaylord Church (C. E. C.), U. S. N.**
- **Five Naval Air Stations in the Vicinity of Brest, France, and Fuel Oil Storage Abroad, by Lieut. C. P. Conrad (C. E. C.), U. S. N. (resigned).**
- **Training Camps at Pelham and City Park, N. Y., by Commander E. C. Brown (C. E. C.), U. S. N. R. F. (inactive list).**
- **Fleet Supply Base, South Brooklyn, N. Y., by Commander E. S. Nugent (C. E. C.), U. S. N. R. F. (inactive list).**
- **Naval Air Station at Chatham, Mass., Naval Training Station at Coddington Point, Newport, R. I., and Aviation Assembly and Repair Base at Eastleigh, England, by Lieut. Commander F. N. Bolles (C. E. C.), U. S. N. R. F. (inactive list).**

Contributions by civilian members of the bureau were as follows:

- **Power Plants, by Mr. L. W. Bates, project manager.**
- **Maintenance and Operating Division of the Bureau, by Mr. Wm. M. Smith, head of division.**
- **Personnel in General, by Mr. E. W. Whitehorne, chief clerk.**
- **Technical Personnel, by Mr. Chas. Morgan, chief draftsman.**
- **Naval Training Camps, by Mr. C. E. Hall.**
- **General Development of Yards and Stations, Storage Facilities, Shipbuilding and Repair Facilities, and Gun Shop, Washington, D. C., by Mr. R. F. Bessey.**
- **Submarine Bases, Emergency Fuel Depots, and General Yard Development, by Mr. L. H. Sinclair.**
- **Bureau Organization, Civil Engineer Corps, U. S. N., Potomac Park Office Buildings, Aviation Stations, and Dry Docks, by Mr. T. J. Mosley.**
- **Naval Proving Ground and Powder Factory at Indianhead, Md., by Mr. W. D. Kneessi.**
- **Civil Engineer Corps, U. S. N. R. F., and Appointments to Civil Engineer Corps, U. S. N., by Mr. L. A. Morrison.**
- **Construction Division of the Bureau, by Mr. E. H. May, head of division, and Messrs. S. L. Wardwell, R. S. Hart, R. J. Potbury, and H. A. Stacy.**

The chief of bureau has acted as editor of this history, aided by Capt. Bakenhus, assistant chief. Mr. T. J. Mosley has reviewed the manuscripts, Mr. William Partridge has had charge of the illustrations, and Miss Edna L. Bemis has prepared the bulk of the contributions for the press.

Very respectfully,

C. W. PARKS, *Chief of Bureau.*

The honorable JOSEPHUS DANIELS,

Secretary of the Navy.

CONTENTS.

INDEX TO ILLUSTRATIONS.

ACTIVITIES OF THE BUREAU OF YARDS AND DOCKS, WORLD WAR, 1917-18.

INTRODUCTION.

PUBLIC WORKS OF THE NAVY AND THE WORLD WAR, 1917-18.

The public works of the Navy comprise practically all construction of shore establishments, such as dry docks, marine railways, shipbuilding ways, harbor works, floating and stationary cranes, power plants, coaling plants, bridges, streets and grounds, radio towers, aviation stations; heating, lighting, telephone, sewer, and transportation systems; and all buildings, for whatever purpose needed, under the Navy and Marine Corps.

Since the passage of the naval appropriation act of April 4, 1911, the Bureau of Yards and Docks has been charged with the design and construction of the public works and public utilities of the Navy, wherever located, and irrespective of the bureau or office of the Navy Department which may use or operate them and the appropriation or fund from which their cost may be defrayed.

Until the United States entered the World War such public works were confined to the United States and its possessions, but later it became necessary to provide public works in countries with which the United States was associated in carrying on the war.

The growth of the Navy in matériel and in personnel during 1917 and 1918 was phenomenal, and public works required on account of this increase cost several times as much as the total value of those works existing at the time of entering the war.

The development of the shore investment in public works was quite marked immediately after the Spanish War, but the pace set immediately after that war was relaxed, and in 1917 the shore establishment was inadequate for the demands then thrown upon it. The Bunce Board in 1897 had pointed out the inadequacy of existing dry docks and proposed a program of dry-dock construction, naming some as immediately necessary and others that should be built later. The present chief of the Bureau of Yards and Docks was recorder of that board, and has followed dry-dock construction with the greatest interest in view of information acquired during the sitting of the board.

The Hon. John D. Long, who was then Secretary of the Navy, acted promptly on the report of the board, and the Congress was so favorably impressed that appropriations were almost immediately made for the construction of four large graving docks and a large steel floating dock. Notwithstanding this and later congressional action in providing for other docks, the number that the board had found to be immediately needed was not completed and ready for use until 1919, when the Pearl Harbor Dock was completed.

In 1897 the value of all public works in the then existing 18 navy yards and naval stations was $53,000,000. The dry docks and buildings were small and old, and were more suited to the repair of the ships of 1860 to 1870 than for the "white squadron" of the eighties. The buildings were inadequately heated and lighted; they were almost devoid of cranes, and the power facilities were insufficient.

For many years after steam propelling engines had been installed in naval ships, most cruising was under sail, and steam was used as little as possible. A few coal sheds, without mechanical equipment, had been provided for storing the small amount of coal that the Navy carried in stock. Shortly after the outbreak of the Spanish War the need for modern and adequate coal storage became urgent, and the Belknap Board made a study of the requirements and recommended that plants with mechanical equipment be built at several points along the coast.

In 1897 the largest ships had a mean draft of less than 25 feet, and one officer predicted that future naval ships would have a draft of not more than 26 feet, since a greater draft would limit the number of harbors that such ships could enter. The vessels then built had not made deep channels and deep berths necessary, and the berths at most of the navy yards were not suitable for ships of greater draft.

In 1898 steps were taken to provide modern shops, a better water front, more dry docks, and improved coaling facilities. Within the next few years the advance in all of these lines was marked.

These improvements made it necessary to increase the several power plants in the navy yards, and it soon became apparent that there was a large duplication in generating apparatus and in distributing systems. To overcome this lack of economy, the naval act of April 27, 1904, provided for centralizing all power plants and distributing systems under the cognizance of the Bureau of Yards and Docks, and, in accordance with this law, a central power plant, serving all activities, has been established in each navy yard and naval station.

The principles established as the result of investigation just prior to and during the Spanish War laid the foundation for the tremendous developments of the World War, and this was simply an expansion and not the inauguration of new principles.

In 1913, at the beginning of the present administration, the value of the public works at the then existing navy yards and naval stations was $191,000,000. This shows a large increase in shore facilities since the year of the Spanish War, but does not show a growth commensurate with that of the fleet.

During the same period a great advance had been made in the establishment of radio stations, and by 1913 about 30 important ones were in use.

After the beginning of the World War, in 1914, a careful survey of the resources of the United States was made, and it was shown that if this country should be drawn into the war it would be necessary to make immense additions to the fleet, the naval shore facilities, and to the merchant marine. The great naval three-year program of 1916 provided for the expansion of the fleet, and provision was made for other necessary things. When the country was at last drawn into the war, the desirable preparations had not been made but, by one of the most complete mobilizations of the whole personnel and material resources of the country that had ever been undertaken, rapid progress was made, and the armistice of November 11, 1918, was brought about by the speed at which the country produced ships and every other feature required for the rapid carrying on of war. During this period the public works of the Navy increased in value from about $211,000,000 to $469,000,000.

To expedite the construction of destroyers and other naval vessels, extensions were made at the plants of private shipbuilders and machinery manufacturers at a cost of about $70,000,000; and much emergency construction was carried out in the countries of the allies and associates in the war. It will be noted that the expenditures for public works of all kinds carried out under the supervision of the Bureau of Yards and Docks during the years of the war were more than the total expenditure that had been made at all navy yards and naval stations during the preceding 125 years.

In the following pages there will be given a more detailed statement of the work accomplished, and of the organization of the Bureau of Yards and Docks and of the Corps of Civil Engineers of the Navy, under whose direction the projects were planned and executed.

CHAPTER I.

THE BUREAU OF YARDS AND DOCKS.

1. DEVELOPMENT OF ORGANIZATION.

Prior to July 1, 1916, the bureau consisted of a chief of bureau, a chief clerk who acted as chief during the absence of the chief of bureau, a small number of civil engineers of the Navy, and a civilian personnel of 59 men and 4 women. While this force had never been large enough to do in the bureau all work that should have been done there, it became evident in 1916 that the bureau organization should be greatly enlarged and that the subordinates should have more definitely assigned duties and responsibilities.

The act of August 29, 1916, created the office of assistant to the chief of bureau, and Commander A. L. Parsons (C. E. C.), United States Navy, was appointed to fill this office. His first duty was to prepare a plan of organization better to systematize the work of the bureau.

Organization of November 1, 1916.—After considerable study, a bureau order was promulgated as of November 1, 1916, embodying a scheme of organization which can now be considered merely as a stepping-stone between two periods of history. By this scheme the chief of the bureau, in general command of all work under the bureau's cognizance, had two assistants acting under his personal direction and independent of all other offices. These were a private secretary and an engineering secretary in charge of data files, library, and specially assigned technical research work.

The bureau's other functions were distributed among the following six "divisions":

(*a*) Office of Assistant Chief of Bureau.
(*b*) Division of Mechanical, Electrical, and Routine Design.
(*c*) Division of Special Design and Projects.
(*d*) Construction Division.
(*e*) Maintenance and Operating Division.
(*f*) Clerical Division.

The general duties of the assistant chief of bureau were to exercise supervision of all correspondence, to prepare the annual estimates for submission to Congress, to supervise organization and office

methods, to coordinate the internal work of the bureau, to supervise the general development of yards and stations, and to act in all respects as the special representative and deputy of the chief.

The principal defects of this organization were (*a*) insufficient specialization in the two design divisions; (*b*) overlapping of functions; (*c*) inadequacy of function, as where an integral activity was carried half-and-half between two divisions; (*d*) building the duties of a division to fit the various acquired proficiencies of the division's chosen head.

Organization of March 26, 1917—Project managers.—These defects were in large part corrected by the organization order issued just 11 days before war was actually declared. This scheme of organization introduced a new vital factor, the real center of the bureau's operations now and the foundation for any future expansion—the project manager.

First, however, as to divisions. The six provided under the organization of November 1 were reduced to three: (*a*) The Design Division; (*b*) the Construction Division; (*c*) the Maintenance, Operating, and Clerical Division. The Design Division combined the functions of the two previous divisions of routine and special design, under the direction of the assistant chief of bureau, who retained general ~~cognizance of~~ for office methods, organization, and coordination of work. The Maintenance, Operating, and Clerical division was ~~an amalgamation~~ of the fifth and sixth divisions of the former scheme, and was placed wholly under the supervision of the then chief clerk, the commissioned officer previously in charge of maintenance and operating functions being relieved as needed for engineering responsibility. The Construction Division alone remained unchanged and was still under the direction of an officer of the corps.

It was in the Design Division that the fundamental change was made. It is in the creative function of design, comprising calculation, drafting, estimating, specifying, that the bureau manifests its true individuality. In the day of smaller things a limited drafting force could be shifted from class to class of projects; an experienced officer could oversee the execution of various types of design at convenience; as late as November, 1916, two groupings of the design function were considered a sufficient specialization. Now the mill was turning faster. New projects were cropping up overnight, old ones were taking a wider scope. Engineering specialists were being called in to handle particular problems; all the officers available for bureau duty found their attention absorbed in those construction projects in which each was experienced. Specialization, in the bureau as throughout the Nation, was the demand of the hour.

Executive personnel of the Bureau, commissioned and civilian.

First row, seated; left to right: Commander McKay, Capt. Bakenhus, Rear Admiral Parks (Chief of Bureau), Rear Admiral Rousseau, Commander Kirby Smith. Second row: Lieut. Bragg, Lieut. Pollard, Commander Cooke, Commander Rogers, Commander Sherman, Lieut. Commander Rouzer, Lieut. Commander Spalding, Commander Southworth. Third row: Mr. Kurrie, Mr. Smith, Mr. Whitehorne, Mr. Bates.

The distribution of work then effected among the seven project managers was the following:

(a) New naval bases and development of existing bases.
(b) Radio, Marine Corps, and fuel-oil station projects; construction for the Bureau of Medicine and Surgery; routine design; dry docks; power plant, Washington yard; subsurface surveys.
(c) Shipbuilding plants and improvements related thereto; gun shop, Washington.
(d) Armor plant and projectile plant, South Charleston, W. Va.
(e) Facilities for aviation and submarines; patrol stations.
(f) Ordnance facilities; storehouses.
(g) Construction at Naval Academy; Research and Experimental Laboratory; duties of executive officer in charge of design division (assistant chief of bureau).

It is to be noted that by this time each project manager was provided with a civilian assistant who was required to familiarize himself with all aspects of the projects in hand so as to be able to carry forward the work in the absence of the manager. Thus was the specialization of project groups clearly demarked; heads of divisions were no longer expected to relieve one another.

Organization, October, 1917, to armistice.—Organization instructions for the bureau were last printed in Bulletin No. 28, Public Works of the Navy, for October, 1917. The scheme was based on several amendatory memoranda issued from time to time after March 26, 1917, and particularly on bureau order No. 121, dated August 6. This plan of organization was very full, precise, and practicable, and continues in force to the present time essentially unmodified.

The number of project sections was increased to 10, as a result both of new demands and of a completed functional distribution. The training camp section had been established since March to meet an unprecedented condition, and was handling a vast amount of work at this time.

The scheme of project assignments was as follows:

(a) Dry docks.
(b) Armor and projectile plant.
(c) Naval Academy.
(d) Magazines and general ordnance facilities.
(e) Aviation and submarine bases.
(f) Shipbuilding and yard development projects.
(g) Marine Corps, fuel oil, radio, and routine projects.
(h) Hospitals.
(i) Power plants.
(j) Training camps.

An information office, formerly under the clerical division, was transferred to the construction division with its functions explicitly

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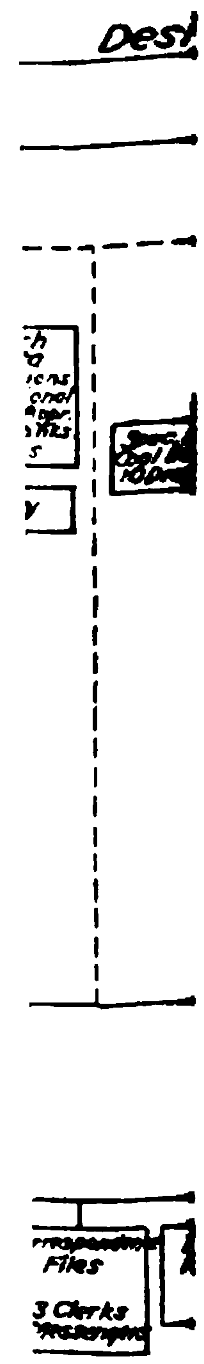

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defined. Its most important duty was (and is) to furnish the connection between the bureau and the building industry. Files of plans and specifications ~~under advertisement~~ were placed under its custody, to be kept in convenient form for the inspection of prospective bidders, materialmen, and subcontractors. Data as to work on hand, ~~in prospect~~, or completed, was to be kept available by this office, and other information concerning the bureau's work in general. This section rendered a vital service during the most strenuous days by relieving the executive chiefs of a mass of inquiries and discussions essential to the execution of contracts.

The organization of the bureau as it existed in August, 1918, was substantially as outlined above, and is represented in the accompanying chart. The 10 project sections enumerated are shown as 9 because of the fact that 2 complete sections (ordnance and aviation-submarine projects) were in charge of a single project manager. The Naval Academy projects are represented as a secondary activity of the assistant chief. A few temporary added functions, such as housing, are charted. These found their places as demands arose. The bureau's relation to the Housing Corporation was advisory only, and had to do with the accommodation of employees under the shore establishment in congested districts.

2. PERSONNEL IN GENERAL.

In March, 1917, the department authorized the enrollment of both men and women in the United States Naval Reserve Force, and the bureau considerably augmented its force through this medium. The maximum number of reservists assigned to ~~this~~ bureau was reached in November, 1918, ~~at which time~~ the records showed the employment of 197 men and 121 women, the women ~~reservists~~ being enrolled to cover the shortage of male employees caused by enlistment and ~~conscription~~, and to perform the work of men.

Under the approval of the President on April 30, 1917, of an allotment to the department from the appropriation "National Security and Defense," contained in the deficiency act approved April 17, 1917, for the employment of experts and high-grade civilian assistants, the bureau brought into its service in a civilian capacity during the time of the emergency a maximum of 24 engineers of high standing in their profession. To these employees the bureau assigned duties of a very high grade and placed on them much responsibility.

There follows a comparative statement of the bureau's personnel, exclusive of officers, as it existed before the World War and at its conclusion, when the force was at its maximum:

	July 1, 1916.			Feb. 3, 1917.			Nov. 11, 1918.		
	Clerical.	Technical.	Miscellaneous.	Clerical.	Technical.	Miscellaneous.	Clerical.	Technical.	Miscellaneous
Men	10	43	6	14	95	7	132	354	31
Women	4			4			167	3	27
Total (bureau)		63			120			714	

As an indication of the increase in volume of business during the war, it may be mentioned at this point that the daily average number of letters handled by the bureau's correspondence files during July, 1918, was 700; the corresponding figure for July, 1916, was 50.

In addition to official duties performed by the civilian personnel, much work of a special character was done by them in the interest of the various "drives" which were launched during the war. A brief résumé in recognition of the effort expended in this class of work would not seem to be irrelevant when we consider the relationship which the results of these activities—that is to say, money and comfort—bear to the successful prosecution of war.

The civilian employees of the bureau took an active part in the conduct of the Liberty loan campaigns, and to them is due in a great measure the bureau's success in these drives. For purposes of canvassing the bureau for subscriptions to these loans in what appeared the most expeditious manner, its organization was divided into classes, embracing both officers and civilians, and each class was assigned to an independent subscription agent; these agents numbered eight, and three of them were women. Owing to their interest in this work, their patriotic viewpoint and pleasing address, coupled with a natural tendency and willingness on the part of the bureau's personnel to contribute to the loans, these agents met with remarkable success in their work. Special attention is invited to the fifth or Victory loan, at which time the bureau went "over the top." The daily bulletins issued by the Liberty loan officer for the department revealed the fact that this bureau alone accomplished this feat.

The splendid results achieved in these campaigns were due not only to the efforts of the bureau's agents, but also to the hearty cooperation on the part of the entire force, both officers and civilians, and the high standard of the morale.

During the period of the war the bureau disposed of war savings and thrift stamps to the value of $40,030.23 through its authorized agents.

Each of the drives in the bureau for contributions to the Red Cross was conducted by women employees, who were very active in this cause. Their efforts met with very considerable success, and contributions were secured from a majority of the officers and employees. Many of the women of the bureau were closely associated with the Red Cross, and contributed much of their time and skill to club work engaged in by that organization for the purpose of providing wearing apparel, such as sweaters, socks, etc., for the boys of the Navy. This work was entirely voluntary, and resulted in very material increase in comfort of the enlisted force of the Navy.

The drive for contributions to the Salvation Army was participated in by the department, and this bureau appointed a representative to solicit subscriptions and make collections. The campaign was quite successful and resulted in generous contributions by the bureau employees.

3. TECHNICAL FORCE.

The need for the preparation of the bureau's organization to receive large volumes of work became apparent early in 1916. The work of securing additional quarters began soon afterwards and was successfully continued throughout the war as demands increased. The matter of obtaining additional technical men proved, however, to be the real problem, and one which was destined to tax resourcefulness to the utmost. The first requests on the Civil Service Commission for lists of eligibles met with excellent results, and men were obtained quite readily. As the demand for technical assistance grew, however, both within the Government service and in the commercial world, the eligible lists were soon exhausted, with but a small percentage of necessary forces secured. It became evident that the custom of the Civil Service Commission of holding competitive assembled examinations had become impracticable in view of the accelerating requirements. This condition was overcome by inaugurating the nonassembled examination, which permitted the applicant to receive a rating and a permanent appointment solely upon statements made in his application. This letting down of the bars facilitated access into Government service, and application papers were filed in the Civil Service Commission so rapidly that it was impossible for their corps of examiners to pass primarily upon each application. Requests for additional technical assistants resulted in the delivery of hundreds of unmarked applications, thus resulting in the task of rating the individual being shifted to the bureau. After the assignment of temporary ratings the papers were returned to the Civil Service Commission and the markings were reviewed by them. After approval certain of the applicants were selected from

the list thus created and were offered positions. All difficulties in obtaining employees did not end, however, at this point. Many of those who were tendered appointments never responded. Some had enlisted for service in the war, some had secured more lucrative commercial employment, and some negotiated for higher pay, which was seldom offered to them.

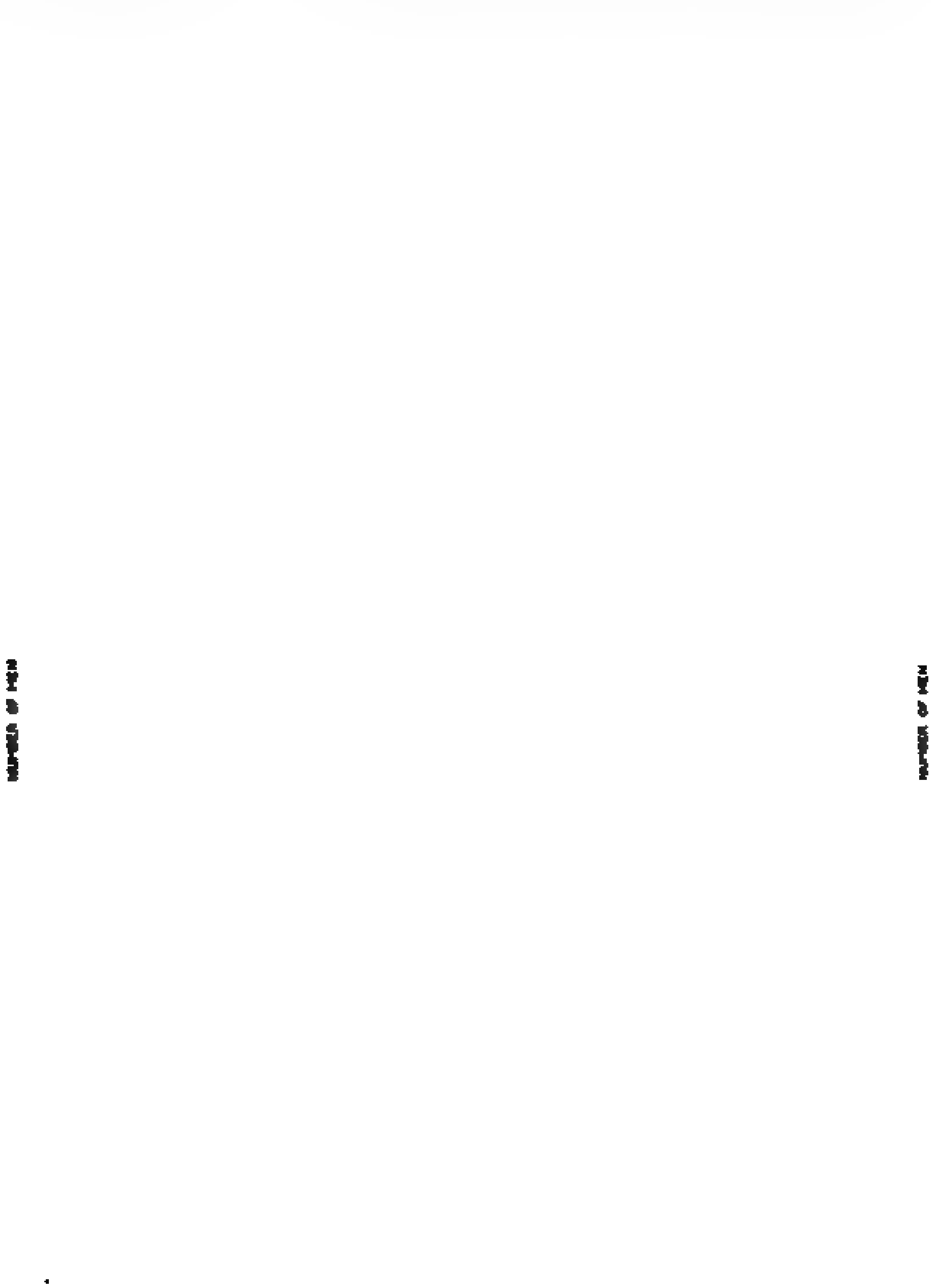
The net result was a relatively small percentage of acceptances, making the growth of the bureau's force too slow to care for the rapidly increasing quantity of work. The supply of applications soon became exhausted, thus rendering it necessary to obtain authority to make temporary appointments, subject to the individual's subsequently filing an application with the Civil Service Commission and sustaining his temporary appointment. This method permitted immediate employment of any applicant to a position, and proved a most successful and efficient method of securing employees. Many excellent men were obtained, and those already employed were requested to communicate with their associates in their previous positions with a view to having them enter the bureau. Every conceivable source was drawn upon for assistance. Many good draftsmen were obtained through the medium of enlistment in the United States Naval Reserve Force. Young men and young women who enlisted in this branch of the service, and who had drafting ability, were given work. The first "draftswoman" that the bureau ever employed entered through this medium. The results of these expedients in the growth of the technical force are illustrated graphically by the accompanying chart, which continues the history of the technical personnel up to October 31, 1920.

The holding of men who were anxious to enlist, after the declaration of war, proved to be a problem. It finally became so difficult that rigid rules were made, and adhered to, which resulted in the retention of most of the aspirants for enlistment honors. The Secretary of the Navy adjudged the work of the department to be essential to the maintenance of the first line of defense at home, and discouraged the enlistment of men who were necessary to the work. Some broke away, however, and joined various branches of the service.

There were no instances of unfaithfulness to the Government among the employees of the bureau. Notwithstanding the fact that some of the most important projects involved in the prosecution of the war were designed and developed by the technical force, a situation which gave ample opportunity for the dissemination of information, no real grounds developed for just suspicion. Close observation was kept on the force and every precaution taken against disloyalty. The antecedents of the men were inquired into, and their

habits, both within the office and on the outside, were studied. Although some were investigated more thoroughly than others, these special investigations developed nothing of an irregular nature.

The conditions under which the technical force labored were excellent. Although crowded at times, there were no complaints or dis-



satisfaction among the men. All practicable provisions were made for their convenience and comfort. The rooms were always bright, clean, and airy, and to this fact is attributed the excellent health of the men during the war period. No cases of serious illness were recorded, and no deaths. During the period when the epidemic of

Spanish influenza threatened to cripple all branches of the Government service, the work of the bureau was not seriously interrupted. It so happened that more of the men lost time on account of sickness in their families than for other reasons.

There is one feature which contributed much to the successful execution of the bureau's work during the war which has not been mentioned, namely, the equipping of the technical force, especially the draftsmen. Probably no branch of the bureau's activities proceeded more smoothly and efficiently than the supply division. When the expansion of the force started, a number of drafting boards and trestles were obtained. These were used temporarily while the regulation equipment was being procured. Too much credit can not be given those in charge of the supplies for the resourcefulness displayed, which resulted in deliveries and no disappointments. Requests for additional equipment and supplies always met with prompt response and delivery. This contributed greatly to the high efficiency maintained by the technical force. Miss Frances Salisbury had charge of this work under the Clerical Division.

Distribution of technical personnel.—Referring to the account of the bureau's organization previously given, it is noted that the bureau's activities were separated into sections, each of which had at its head a "project manager." Certain assistants were assigned to the project manager, who aided him in supervising work in hand. To each project section were attached a corps of draftsmen and technical men divided into squads, each of which had its squad leader. The number of technical men in each section varied from 1 to as many as 75, while the number in a squad varied from 1 to 8 or more. Most of the sections finally developed into independent and general drafting forces—that is, each contained draftsmen of various callings, thus enabling the project manager to undertake and complete any assigned project without assistance from other sources. The principal sections, and the number of draftsmen included therein on January 1, 1919, are as follows:

	Draftsmen.
Armor and projectile plant section	16
Shipbuilding and yard development section	60
Magazines, storehouses, general ordnance, aviation, and submarine base section	73
Training camp section	16
Marine Corps, fuel oil, radio, and routine section	22
Hospital section	23
Dry dock section	5
Power plant section	27

If the urgency or volume of work in one section became such as to require additional men, they were procured from other sections where work would permit their release. Transfers of this nature were not always easily accomplished on account of the desire of each section head to keep his organization intact. A hearty spirit of co-operation, however, prevailed at all times, as a result of which the technical employees were placed where they were most needed. The outcome of all issues was unfailingly effected with a continuance of good feeling and mutual respect among all concerned. The experience through which supervisors, as well the men, passed during the World War was one which will long be remembered as something well worth while and well done.

37022—21——3

CHAPTER II.

THE CORPS OF CIVIL ENGINEERS, UNITED STATES NAVY.

Public works of the Navy are now designed in the bureau under the direction of officers of the Corps of Civil Engineers, and construction in the field is carried out under the direction of officers of the same corps. Officers of this corps also serve as public works officers at the navy yards and naval stations and have charge of the maintenance and repair of public works and public utilities. These officers have cognizance of projects in almost all branches of engineering, and, before appointment, have been obliged to undergo an exhaustive professional examination. The origin and growth of the corps is considered of interest.

The official connection of civil engineers with the Navy dates back to an early period of the country's history; the growth of the civil engineering force into a commissioned corps of its present strength has been a gradual development.

President Jefferson, years before the Bureau of Yards and Docks was established or the corps organized, conceived the idea of the construction of a huge dry dock capable of accommodating 12 frigates. It will be remembered that at this time ships of the line were built of wood, and were very small compared with present-day standards. Jefferson's idea was to have a tide-water basin from which ships could be raised by locks to an upper basin, 24 feet higher. The upper basin was to be 800 feet long and 175 feet wide. After the water was drained out of it, the ships would be left high and dry. Benjamin Henry Latrobe was called in as consultant on this scheme. He considered it feasible and executed the drawings, but the project failed of accomplishment because a congressional appropriation could not be obtained for it.

The connection of Latrobe, an eminent civil engineer, with a naval shore project such as the foregoing indicated the essential relation between fleet and land construction which has since continually grown closer.

The next notable instance of a similar character occurred within the period of administration of the Board of Naval Commissioners, with the employment of Loammi Baldwin, jr., on the construction

of the dry docks at Charlestown (Boston), Mass., and Gosport (Norfolk), Va. Born in Massachusetts in 1780, the third son of a colonel in the Continental Army who was himself an engineer of repute, Loammi Baldwin numbered among his early works a noteworthy dam on the Union Canal, in Pennsylvania, the construction of the Bunker Hill Monument and the water supply system of Boston. The Boston and Norfolk dry docks, the great works of his life, were built concurrently from identical plans during the years 1827 to 1834. His assistants were Capt. Alexander Parris and W. P. S. Sanger at Boston and Norfolk respectively. The two docks thus built are still in commission, unexcelled examples of their era.

In addition to this work, Baldwin was engaged in 1827 as consulting engineer to a body of commissioners to examine the various navy yards and form plans for their future improvement. From 1826 to 1835 he made surveys of New York Harbor to determine the best location for a dry dock. This work, however, was not carried out until after his death. He furnished complete plans for a marine railway at Pensacola, Fla.

The administration of the Board of Naval Commissioners was superseded by the bureau system by authority of law in 1842. Only five bureaus were at first provided for, the first to be named being a "Bureau of Navy Yards and Docks." The personnel of the first force of this bureau included W. P. S. Sanger as "Civil Engineer," the same Sanger who was Baldwin's pupil and assistant in the construction of the Norfolk Dry Dock.

It was not long until civil engineers, attached to the Bureau of Yards and Docks, were regularly employed at the various yards as well, and in 1858 a series of rules was drawn up for their regulation and guidance. These rules defined the duties of the civil engineer very much as they have existed to the present time. Until 1867 the civil engineers of the Navy retained a strictly civilian status, but in that year Congress passed a law providing that the President might appoint the civil engineers, such appointment to be confirmed by the Senate. This act made the civil engineer a staff officer. Four years later Congress provided that civil engineers should be given such rank as the President might fix, and limited their number to 10.

The first civil engineers to be commissioned under the act of 1867 were: W. P. S. Sanger, F. C. Prindle, B. F. Chandler, F. A. Stratton, and Chas. Hastings. On account of his seniority in service, linking back into the beginnings of the Navy, W. P. S. Sanger may be justifiably considered the first civil engineer of the Navy.

He retired from active service with the relative rank of captain in 1881, and died in Georgetown, D. C., in 1890. He was the principal engineer in the Bureau of Yards and Docks from its inception to

the day of his retirement. No naval engineering board was complete unless he was a member of it. He took a prominent part in the building of the Mare Island navy yard and in the development of all the others. He shaped the early career of the corps more than any other one man connected with it.

The strength of the corps remained fixed at 10 until long after the close of the Civil War, the period from 1867 to 1883 being one of pronounced naval inactivity, not to say stagnation. At the outbreak of the Spanish-American War, however, the number of civil engineers was increased to 18 through discretionary powers vested in President McKinley. Further increases were secured through the efforts of Rear Admiral Mordecai T. Endicott, who was chief of the bureau from April 4, 1898, to January 5, 1907. The small corps of 18 was wholly inadequate to the requirements of an expanding navy, and an increase to 40 (28 full civil engineers and 12 assistants) was authorized by act of Congress on March 3, 1903.

The naval act of August 29, 1916, frequently called the preparedness act, based enrollment in the Corps of Civil Engineers upon the percentage of line officers, and thus on the strength of the enlisted personnel of the Navy. This percentage is eight ten-thousandths of the total authorized active enlisted strength, but is somewhat less than it should be to carry on work satisfactorily for both the Navy and the Marine Corps.

The same act established a Naval Reserve Force and permitted the enrollment of civilians in class 4, complement of the Naval Reserve Force Civil Engineer Corps. During the spring and summer of 1917 several reserve officers were enrolled. In the fall a nonassembled examination was held, and from about 7,000 applicants an eligible list of 335 candidates was established.

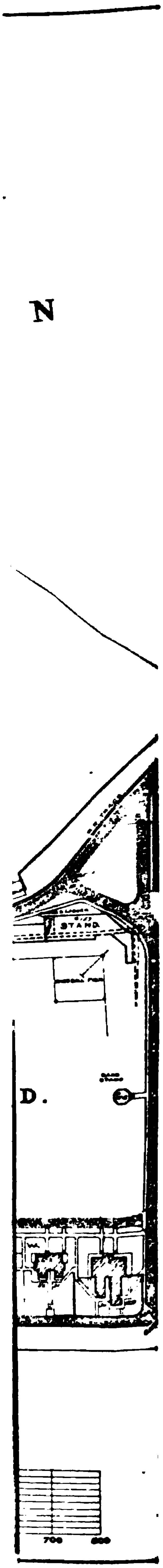
On the date of the armistice the Civil Engineer Corps consisted of 74 regular officers, 20 temporary officers, and 110 reserve officers.

Rear Admiral Endicott (1898) was the first Chief of the Bureau of Yards and Docks to be appointed from the Civil Engineer Corps. Before his term of office was completed, the rule was established by law (June 29, 1906) that thereafter the chief of the bureau should be selected from members of the corps exclusively. The logic of such an enactment should be at once apparent. It was further provided in the law of August 29, 1916, that an officer of the corps might be detailed as assistant to the chief of bureau.

Rear Admiral Endicott was succeeded as chief of the bureau by Rear Admiral H. H. Rousseau, who was selected as a Commissioner of the Panama Canal less than three months after his appointment. Rear Admiral R. C. Holliday served as chief four years and nine months from March 26, 1907. Under his administration the con-

solidation of all public works of the Navy under the Bureau of Yards and Docks was accomplished.

Rear Admiral H. R. Stanford took office on January 14, 1912, and served as chief of the bureau four years. Rear Admiral F. R. Harris was appointed January 14, 1916. His administration embraced the opening period of the Great War, and was marked by an unprecedented expansion of the bureau's activities. He resigned to become general manager of the Emergency Fleet Corporation, and was succeeded by Rear Admiral Charles Wellman Parks, the present chief, on January 12, 1918. Capt. R. E. Bakenhus is the present assistant chief of the bureau.



olis, Md.

CHAPTER III.

NAVAL ACADEMY, ANNAPOLIS, MD.

At the outbreak of the war it was apparent that the training facilities for officers and men would not care for the large number that must be taken into active service.

Bancroft Hall, the dormitory of the Naval Academy, had been designed for 500 midshipmen, but had from time to time been rearranged to accommodate 1,200. Further to increase the dormitory accommodations it would be necessary to make additions to Bancroft Hall; and, as it was estimated that accommodations should be provided for 1,000 more midshipmen, plans were prepared for the construction of two new wings.

The work was authorized by Congress and an appropriation of $1,000,000 made on March 4, 1917. A contract was awarded on July 13, 1917, for the construction of the two wings. One of the wings was occupied in May, 1918, and the second in September, 1918, together providing quarters for 1.200 midshipmen and bringing the total capacity of the Naval Academy to approximately 2,400 men. The east wing and south wing are connected to Bancroft Hall not only by interior corridors, but also by a wide terrace surfaced with promenade tile, which forms the roof of the mess hall. The terrace affords several entrances to the buildings and provides quick and easy access to the dormitories. Considering the fact that the buildings are of reinforced concrete construction with Maine granite exterior walls, the time of completion for the work was short.

The naval act of July 1, 1918, increased the limit of cost of the Bancroft Hall extension from $2,270,000 to $2,850,000. Owing to the unsettled conditions of the building trades and the excessive and constantly rising costs of labor and building materials due to war conditions, two additional deficiency appropriations were made. The appropriations for the Bancroft Hall extension are summarized as follows:

Act of March 4, 1917	$1,000,000
Act of July 1, 1918	1,850,000
Act of Feb. 25, 1919	750,000
Act of July 11, 1919	325,000
Total	3,925,000

The original classroom and laboratory facilities at the Naval Academy proved insufficient for the increased number of midshipmen, and two appropriations were made by Congress to meet the requirements: One on June 15, 1917, of $300,000 for an addition to Isherwood Hall; and a second on July 1, 1918, of $1,000,000, with a cost limit of $2,500,000, for a building for seamanship and navigation and other instruction purposes. Of the $2,500,000 authorized for the seamanship and navigation building only the $1,000,000 as appropriated was used. A contract for the addition to Isherwood Hall was made on August 6, 1917, and a contract for the seamanship and navigation building, Luce Hall, was made on March 31, 1919. To provide intensive training for reserve officers, two temporary wooden buildings were erected in the vicinity of Bancroft Hall, and were finished complete with bedrooms, study rooms, and messing arrangements.

The addition of the dormitory and educational buildings necessitated an enlargement of the power plant and distributing systems of the academy. On July 1, 1918, an appropriation of $325,000 was made for improvements to the central power plant and distributing systems, and on July 11, 1919, $200,000 was appropriated for an addition to the power plant.

The construction authorized by Congress to care for the expansion of the Naval Academy added four permanent and two temporary buildings to the group already erected. The buildings are of monumental character, of a French academic style, and are constructed of reinforced concrete with granite facing. By the addition of the east and south wings to Bancroft Hall, an imposing U-shaped court was formed, opening on Farragut Field (the parade ground) and affording a view of Chesapeake Bay just beyond the sea wall of the field.

Bancroft Hall extension, east wing, Naval Academy, Annapolis, Md.

Seamanship and Navigation Building, Naval Academy, Annapolis, Md.

CHAPTER IV.

NAVAL TRAINING CAMPS.

In the spring of 1917 there were in existence four naval training stations in the United States. These had a total capacity of 6,000 men. The largest, at Great Lakes, Ill., with accommodations for 3,000 men, was opened in 1911, with an initial capacity of 1,500 recruits. The oldest, that at Newport, for 2,000 men, was commissioned in 1881, although it had theretofore been a year in operation. One at Yerba Buena (Goat) Island, San Francisco Harbor, established in 1889, and one at St. Helena, Norfolk Navy Yard, established in 1908, had a capacity of 500 men each. The establishment of these stations was the result of a demand for a more scientific training of the recruit than the old training ship produced. The Navy gave up the system of sending recruits to such ships, and substituted the training-station courses for their disciplining and preliminary technical instruction. The increasingly complex battleship, with its concomitant destroyers, colliers, supply ships, etc., demanded many specialists. These crews must all be given a uniform training, a foundation, before a choice or an allotment of rating was allowed; and trade schools were established for the training of ambitious reenlisted men or of recruits showing special aptitude.

The establishment of stations central to recruiting districts aided rapid enlistment; isolation of the men in small groups before and after training aided in stamping out disease and proved the most efficient method of supplying effective, healthy men and protecting the seasoned men already with the fleet.

Uniform preliminary training in fundamentals provided a foundation for future specialization and developed resourcefulness in the recruit, no matter to what branch of the service he was finally attached. Replacements and new units necessitated a steady flow of men.

That the system on which these older schools was founded was sound and flexible is shown by the facility with which the land-trained crews adapted themselves to the requirements of the new arms—seaplanes, balloons, and submarines. The final test came during the war, when the Great Lakes Station alone, averaging at

first 200 new men a month, finally received in July, 1918, 28,000 recruits in that one month.

The system stood the strain of a total enlargement from four stations with 6,000 men in training at the beginning of the war to 40 stations, established or under construction, with accommodations for 191,000 men in winter and 205,000 in summer, at the signing of the armistice.

Some conception of this growth can be gleaned from the fact that $1,500,000 was originally contemplated as a sufficient sum for naval training camps, whereas $75,000,000 had been appropriated or spent at the cessation of hostilities.

This rapid enlargement required immediate construction of a vast number of buildings necessarily temporary in character, their locations in many cases unprepared for building sites; but their erection was done at maximum speed with all possible economy at a period when priorities in material and transportation were problems of the gravest import.

Not only were buildings provided for barracks, mess halls, and schools, but drill grounds, athletic fields, roads, paths, heating and power plants and their feeding and lighting conduits, water supply, sewers, and drainage, were all laid out at maximum speed to meet not only the requirements of the moment but also possibilities of indefinite expansion.

Upon the Bureau of Yards and Docks, charged with the construction of all shore establishments of the Navy, fell the responsibility of designing and erecting the necessary training station facilities. Work was begun only upon our entering the war, and a rigid survey was made of the special requirements of naval training camps. Studies were based on the experience of the few existing establishments, and took large account of their organization and operation.

Designs were made for a chain of 20 cantonments linking up both coasts with the Great Lakes and providing accommodation for 80,000 recruits. This was sufficient for the immediate emergency only, and a continual expansion, both in number of stations and capacity, kept pace with the increase of the Navy as a whole.

It is a matter of some satisfaction to the bureau that its organization in 1917 enabled it to conduct its emergency naval camp construction with a remarkable measure of success. Early contracts were made on the cost-plus basis, but the interests of the Government were safeguarded by careful inspection and supervision. While this form of contract, in general, may be subject to debate on grounds of economy, it proved for the time being the most speedy, and resulted in the early completion of the buildings so absolutely necessary for the accommodation of recruits. The time of completion of each camp was short. An extension of the Great Lakes station to

accommodate 17,000 men was finished in four months. The first training camp at Hampton Roads for 10,000 men was completed in three and one-half months, three weeks of which time was consumed in draining, stumping, and clearing the site, over 4,000 workmen being employed in this alone.

At the Philadelphia Navy Yard site cantonments for 5,000 men were built in three months. In Brooklyn, quarters for 3,000 men were erected in 30 days.

In several cases the work of construction was done by enlisted men of the Navy, in others by navy-yard labor employed under the supervision of public works officers, and the large remainder was handled through commercial contracts.

During the peak of construction, 50,000 men were employed on the training camp projects alone. The results are a source of great pleasure when the hampering elements are considered. The buildings are admirably arranged on architectural lines with simple masses, all exposed surfaces are painted, and at this writing grass and planting enhance the central features of the stations.

Close cooperation with the Bureau of Medicine and Surgery was maintained in the planning of these training camps to meet the Bureau of Navigation's demands for an ever-increasing expansion of facilities, and all credit attaching to the control of sickness in these establishments during the war is due to the Bureau of Medicine and Surgery for the rigid requirements and remedial suggestions laid down by it.

TRAINING ASHORE—THE SYSTEM.

For a proper understanding of the conditions governing the plan of a naval training station, an insight must be had into the daily life of the recruit it houses.

Upon his arrival at the station he is held for observation for 21 days in what is known as the "incoming" isolation group, and is housed in a barrack accommodating 12 men. If he is infected with any communicable disease, it will develop in that length of time and only 11 men will have been exposed.

In this detention camp he is under constant medical observation, and for the protection of the main camp he is isolated by a zone 10 feet wide formed by two high barbed-wire fences. Each unit has its own dormitories, mess room, serving room, and latrine. His food comes in vacuum containers from a special centrally located kitchen. His dishes never leave the building, but are sterilized in each serving pantry. His clothes, however, are taken to the general laundry in special bags and sterilized before being laundered. This isolation camp is provided with its own dispensary, officers' quarters, and barracks similar to those in the main regimental group.

At the end of his three-week period of medical observation he is enrolled in a regimental training unit and is housed in a barrack containing from 54 to 140 men. He now advances in his training, a landsman to be made into a sailor before treading the deck of a ship. He sleeps as a rule on a stout canvas hammock slung 6 feet above the deck, as the floor is called. That hammock he suns daily on a long pipe railing just outside the barrack. His spare garments are stowed in a clothes bag kept lashed with a clove hitch to a jackstaff in precisely its proper location. His valuables are locked in a ditty box stowed in its proper niche on a steel rack.

He spends an allotted portion of his time in a building provided with a scrub deck for washing clothes exactly as on shipboard. He takes his meals in a large, airy mess hall accommodating from 2,000 to 5,000 men, equipped with regular tables and benches and the full outfit of mess gear. His working day is divided by Navy bugle calls into school, drill, guard duty, and fatigue. His drill is conducted in bad weather in a huge hall 100 by 600 feet with an unbroken roof span, one such hall being provided for each 5,000 men. A dock is equipped for his training in handling small boats, with davits for raising and lowering these and a boathouse for their storage. Rowing tanks and swimming pools are provided for his instruction in oarsmanship and swimming, and even his athletic amusements are planned to develop his sense of teamwork, as it has been found that the battleships flying the efficiency pennant are usually the ones the members of whose crews furnish the winning athletic teams.

His evenings are spent in study or recreation, and the Y. M. C. A. and K. of C., as well as hostess houses, give him a variety of choice.

After a period of training whose length is governed somewhat by the demand for men for the fleet, he is withdrawn into an outgoing detention or isolation camp, under the same conditions as when he entered, for the same period of time, so that any possible disease he may have contracted during training, in spite of careful medical supervision, will develop, and so protect the crew to which he will be assigned.

To house, subsist, and instruct even 5,000 recruits a large number of buildings are required, and these must be so located and planned as to minimize costs and time in both communication and operation.

The barracks, accommodating from 54 to 140 men each, are arranged in regimental units, each with its own mess hall, galley, dispensary, and attendant buildings.

The regimental barracks are further subdivided into brigade units, each with its proper headquarters. Schools, drill halls, a physical instruction building, and swimming pools are apportioned to 5,000-man units. The camp as a whole must be equipped with a heating and power plant, storehouses, fire engine houses, telephone service,

garbage incinerator, and shops, as necessarily as a city requires its public utilities.

These buildings are grouped in the following main divisions:

1. Administration group.
2. Isolation group.
3. Main regimental group.
4. Service group.
5. Hospital group.
6. Educational and recreational group.

The administration group occupies a central location, and comprises the buildings or building for office administration with proper subdivisions for executive and general offices. Officers' quarters, officers' mess and kitchen canteen, warrant officers' quarters, armory, wireless station, and telephone central complete the group.

The isolation group has been briefly described above. The 12-man barracks in its "incoming" and "outgoing" halves are each completely self-contained, with all living facilities under one roof.

The main regimental group is composed of barracks, latrines, mess halls, dispensaries, scrub decks for washing clothes and hammocks, a regimental office building for every regiment, brigade headquarters for every brigade, cooks' barracks, officers' quarters, chief petty officers' quarters, and a regimental quartermaster building, and in this group lie the parade ground, athletic ground, fire engine house, drill halls, and physical instruction building.

The commissary group contains the storehouses, refrigerator plant, bakery, and general store building for supplies, clothing, and camp equipment.

The service group contains the buildings for garage, blacksmith shop, carpenter shop, electrical shop, paint shops, central heating and power plant, coal handling apparatus, garbage incinerator, and other necessary services; water plants, water supply filtration, sewage disposal, service roads of concrete, walks, of either cement or wood, and the lighting of grounds and flood lighting of the boundary fencing also fall under this group.

The educational and recreation group contains buildings especially equipped for the various purposes. In it may be found a general school, commissary school, rigging school, carpenter school, yeoman school, electrical school, music school, swimming school, radio school, and officers' school.

The recreation buildings, if any, are equipped for moving pictures or entertainments, although the Y. M. C. A. and K. of C. usually have their own recreation buildings and comforts.

The buildings are constructed of wood, erected on wood or concrete posts, except those in which concrete floors are required. The sills, floors, and beams are of wood, the floors double-laid with water-

proof paper between courses. The walls are sheathed inside with matched or composition board. The outside walls are sheathed, except in the southern climate. A layer of tarred paper is used for this purpose, and the sides are covered with drop siding of vertical boards and battens. The roofs are sheathed solid and are usually covered with ground slag or ready roofing.

Every possible comfort is afforded that good discipline permits, and every known medical precaution protects the health of the personnel.

THE CAMPS AND STATIONS.

This brief description of the general facilities required in a training camp gives slight conception of the magnitude of a camp project in its entirety, nor does it suggest the variations of the general scheme required for the several classes of training at different locations.

The Bureau of Navigation, in governing the training operation, assigned to each camp certain schools of special instruction. These schools, of course, required special facilities in addition to the ordinary requirements of general training. While some of these schools were housed in existing structures, necessitating in such cases no actual building construction, the equipment and necessary improvements were provided by the Bureau of Yards and Docks in all instances.

Building construction was carried on at the various locations indicated below, and in the following brief on each of these places no detail has been attempted. The intention is merely to emphasize the almost simultaneous growth of the several stations, since it would be impossible within the compass allowed to go into the variations of design and equipment for improvement of all places of training and instruction provided for the Navy during the emergency.

FIRST NAVAL DISTRICT.

Receiving ship, Boston, Mass. (*Commonwealth Pier.*)—On April 19, 1917, the receiving ship personnel were transferred from the navy yard, Boston, to the Commonwealth Pier, South Boston. Certain parts of this immense inclosed structure, belonging to the State of Massachusetts, were leased by the Navy; and with the installation of a heating system and toilet facilities, together with the proper equipment, comfortable accommodations were soon provided for housing and messing 2,500 men.

Training Camp, Bumkin Island.—Early in May, 1917, Bumkin Island, in Boston Harbor, was leased from its owner, Mr. A. C. Burrage, a Boston philanthropist who had erected on the island a large building for use during the summer as a children's hospital. On

May 28, a few officers and men arrived at the island and, using the hospital as quarters, began preparing a training camp. Barracks were occupied as fast as built, the arriving recruits dividing their time between general training and constructing barracks for more men. During July contracts were awarded for additional barracks, drill and mess halls, together with heating, lighting, water, and fuel systems. By November a model camp for 1,000 men was complete, utilizing the hospital building for administration, hospital, and officers' quarters.

Realizing the possibility of overcrowing and the resulting detriment to the health of men housed at all stations, the Bureau of Medicine and Surgery early in 1918 prescribed certain minimum allowances for sleeping quarters. These specifications required that a minimum of 50 square feet of floor space and 450 cubic feet of air space be provided for each man, with the further requirement that 5 feet be maintained from head to head of men sleeping. The situation often prevented immediate observance of these provisions. In the present case, however, every effort was made to meet them, and in July, 1918, a contract was awarded which supplied housing designed to accommodate 1,100 additional men on the basis of the prescription. This work was completed in the latter part of the year, and with the quarters already in use a total capacity of 1,750 men was provided.

Training Camp, Hingham.—Available ground at the naval magazine, Hingham, Mass., was authorized as a site of a camp in April, 1917, and a contractor then constructing buildings at the magazine was instructed to build certain temporary structures for camp use. Additional barracks, together with heating and other appurtenances, were contracted for in September, which when completed, in October, 1917, provided a camp for approximately 600 men. Fire-protection system, dispensaries, water supply, and a 1,100-man extension to the camp were completed under contract by October 17, 1918.

It is interesting to note that Hingham was originally planned to serve as a quarantine camp in case of an outbreak of contagious diseases on Commonwealth Pier, the capacity of Bumkin Island having become inadequate. When the first part of the camp was completed, in the fall of 1917, recruits destined for general training were sent to Hingham for outfitting and a three-weeks period of detention and preliminary training, and were then transferred elsewhere to complete their course or assigned to special training, this being a point of selection for special instruction schools. When the condition arose which the Hingham camp had originally been designed to meet (influenza epidemic of August, 1918) it was not available, being fully occupied for indispensable training purposes. The

situation was met, however, by the establishment of tent camps on the State muster grounds at Framingham, Mass.

Harvard Radio School, Cambridge, Mass.—In mid April, 1917, through the courtesy of Harvard University, a school was established in the Crufts Laboratory to meet the demand for men trained in radio work. The men were messed by the university at a cost of $5 each per week, and were housed in a college dormitory at $3.25 per week, paying their expenses from their subsistence allowance of $1.25 per day. It was not long before the school had reached its total possible capacity of 500 men, and expansion was provided by a further arrangement with Harvard College for an additional 500 men. This, however, did not suffice, and it became necessary to construct barracks and instruction buildings on land in the vicinity. The mayor of Cambridge was requested to offer the Navy the use of Cambridge Commons. This he did, and after some local opposition had been overcome, ground was broken on June 6 for the erection of barracks for 1,800 men. The work was completed in 43 working-days, and provided complete facilities for quartering and instruction, the messing being continued under an arrangement with the university. Perhaps one of the items of greatest interest in the design of this camp was the objection of local authorities to defacing their park by cutting down trees, and the obvious difficulty was experienced of designing buildings and locating them so as to avoid the planting. As the work was finally accomplished, only three trees were removed, with the result that this camp presented, no doubt, the best appearance of any built during the war period. The buildings, painted a low-visibility green amid the heavy foilage, presented an appearance of long existence rather than temporary expediency.

Fuel-oil school, Quincy, Mass.—Contracts for a large number of destroyers had been awarded to the Bethlehem Shipbuilding Corporation at this point, and in order that trained firemen, at least familiar with the vessels to which they were to be detailed, might be available upon completion of a ship, a fuel-oil school was established at this site. The school was operated for a while in plant buildings, but increasing numbers which were required led to the authorization in June, 1918, of the construction of a barracks and instruction building for 100 students.

Prison camp, Portsmouth.—With the expansion of the Navy it is only natural there should be a proportionate increase in prison facilities. However, only one important addition to shore prisons was made during the war, and that at the site of the naval prison in the navy yard, Portsmouth, N. H. On December 15, 1917, the Bureau of Yards and Docks wrote Portsmouth that at a conference between the Secretary of the Navy, the Judge Advocate General, and a repre-

sentative of the bureau it had been decided to make immediate additional provision for prisoners by the erection of temporary buildings. It contemplated immediate construction for 300 prisoners; ultimate expansion to a capacity of 1,000. In the yard's reply facts were brought out which indicated that the immediate need was greater than that contemplated, and acting upon these recommendations and the authority of the Secretary, the bureau prepared plans for the award of a contract on December 29, 1917. This contract provided for the construction of barracks, a mess hall, and other facilities for housing 500 prisoners. Almost before the work was begun the necessity for further expansion was realized, and facilities increasing the total to 840 men were added to the contract. This work was completed April 13, 1918, and still greater enlargement was contracted for in August, 1918, which, when completed in December, 1918, increased the capacity of the temporary prison to 1,384 men.

Marine barracks for prison guard, Portsmouth, N. H.—This project is dealt with in the chapter on Marine Corps construction.

SECOND NAVAL DISTRICT.

Training Station, Newport, R. I. (Coaster's Harbor Island).—As previously mentioned, the Newport Training Station is the oldest of the permanent training establishments, and at the declaration of war was capable of handling 2,000 men. The buildings were of a permanent type but few in number and were not adapted to the accommodation of any considerable increase in complement. The War College building is located on this island, and with the closing of the college this building was occupied as camp administration and district headquarters. Tents, cots, and other necessary matériel were purchased to care for the surplus influx of men to be trained here, the population of the island being reported as 6,000 on May 10, and 10,000 on July 10, 1917.

In the meantime every effort was being put forth to replace tents with suitable habitation, temporary barracks being constructed on nearly all available spaces, and by fall the winter quarters had been increased to house a total of 8,000 men. The heating system for this camp presented an interesting problem, the desirability of constructing several temporary units or one central power plant of a more permanent type being debated.

In this connection a few words from Capt. Bennett's history of the training division, Bureau of Navigation, are found of interest:

> The heating problem at the Newport Training Station was deemed sufficiently important and peculiar to warrant building a complete and permanent new central power plant, rather than provide a number of smaller isolated units

Temporary barracks and permanent construction, Naval Training Station, Newport, R. I.

Temporary barracks, Naval Training Station, Newport, R. I

as was done at Great Lakes and in most other stations and camps. Conditions surrounding the execution of this contract were such that, despite early letting, it was not completed in time to take over the whole load of the station during the winter of 1917–18, thus causing the commanding officer many serious hours during that trying winter. With its assistance, in its partially finished state, the living quarters of officers and men were, however, kept heated and lighted. It may not be inappropriate to remark, for the benefit of those charged with similar responsibility in the future, that for quick and certain results temporary construction would seem to present certain advantages, even though the need for additions of a permanent nature be fully recognized and allowed to proceed simultaneously.

In meeting a heating problem such as the above, one must keep in mind the necessity for economical operation. The difficulties presented by supervision as well as those of transporting fuel, supplies, and débris must always be weighed against the economy of centralization, the housing of the plant being only a minor factor.

Coddington Point, Newport, R. I.—Further expansion of the camp on Coaster's Harbor Island, although recommended by the commanding officer, was not considered advisable by the Bureau of Navigation. It did, however, advocate the purchase of a tract of land to the northeast of the island on the mainland, the only separation being a narrow arm of the bay navigable only by the smallest craft. This tract is known as Coddington Point.

On April 17, 1918, the mayor of Newport wired the Secretary of the Navy offering this land to the Government for $100,000, the city having procured an option at $150,000, and being willing to pay the difference. Eventually Congress appropriated the necessary funds, and this 161.4 acres was made available for another camp as an adjunct of the training station, Newport.

Just at this juncture the United States Shipping Board called upon the Navy to be prepared to furnish 200,000 trained men for their ships listed for delivery prior to January 1, 1920, and the Bureau of Navigation then felt that the time had arrived to provide a large increase at Newport. A camp for 15,000 men, with necessary additional auxiliary buildings, incoming and outgoing detention groups, and a ship's company unit was contemplated. Bids for this work were opened on August 26, 1918, and the contract was awarded within a day or two thereafter.

The construction of this camp with all facilities for heat, light, and power, together with roads, walks, sewer and water systems, fences, street lighting, fire-pressure mains, sewage-disposal plant, piers, and coal-handling devices was pursued rapidly. When, however, the signing of the armistice caused sudden and radical changes in all plans contingent on the prosecution of the war, the development of Coddington Point was at once arrested. The capacity of the camp as completed was only 8,000 men.

Delay incident to the curtailment of contracts for this work, as well as the passing of the emergency, hindered the completion of even this reduced portion until early in 1920. (See note at end of chapter on the latter phases of this project.)

Cloyne Field, Newport, R. I.—Reports from the second naval district during April, 1917, indicate particularly energetic enrollment of recruits. In fact, it is said that in mid April the training station had been filled with regulars, and soon thereafter all the accommodations of the shore establishment and on the few small vessels of the district had been filled. Men were quartered in the Y. M. C. A., a church building, and elsewhere, and new men continued to arrive at the rate of 75 per day. Newport could offer very little in the way of accommodations, and attempts to lease additional facilities were for a time unavailing.

About May 1, however, the commandant obtained a lease on the athletic field belonging to the Cloyne School of Newport. The construction of a camp was begun promptly, and within four weeks 600 men moved into the barracks completed. Others followed as completion progressed. The original capacity contemplated was 1,000 men, but before this figure was reached a second 1,000-man unit was authorized and added. In compliance with the requirements of the Bureau of Medicine and Surgery, previously explained, the capacity of this camp was afterwards officially designated as 1,600 men.

Submarine Base, New London, Conn.—While training was actually carried on and barracks for housing the men were constructed at New London, the activities were properly those of a submarine base and are alluded to in the chapter so designated.

THIRD NAVAL DISTRICT.

At the beginning of hostilities there were a number of battleships and several other men-of-war in a reserve status at the navy yard, New York, and several auxiliary vessels were sent to this yard to be fitted out. These, together with ex-German merchant ships later sent to the yard to be fitted as troop ships or cargo transports, were utilized for housing recruits and members of the Naval Reserve mobilized at this point. There were only three places ashore available for housing and instruction, with a total capacity of approximately 1,500 men. These quarters were immediately occupied. They comprised the U. S. S. *Granite State*, moored at a pier in the Hudson River at the foot of Ninety-sixth Street, accommodating about 400 men, and assigned to the Naval Militia; the Naval Militia Armory at Fifty-ninth Street, Brooklyn, locally known as the " Fed-

[illegible] Pelham Bay, N. Y.

eral rendezvous," providing for 600 men; and the naval Y. M. C. A., near the yard, where about 500 men could be housed and subsisted. These did not begin to meet the demands for quarters, and a tent camp for 1,000 men was established at Tarrytown, N. Y., but was abandoned in the early winter of 1917. Another summer camp was established at Summerville, N. Y., for about 600 men. However, the need for further expansion was soon paramount, and, upon the authority of the department, what was afterwards known as Base Six, in reality a hotel at Bensonhurst, Long Island, was leased, thereby releasing the three locations previously mentioned for special school purposes.

Bensonhurst was soon known as a training camp of the third district, and continued operating as such until the occupancy of Pelham, when general training was discontinued and only special classes of instruction were maintained. Its normal capacity was only 1,200 men, and this was far exceeded in the summer of 1917.

On August 4, 1917, the director of training (Bureau of Navigation) reported in part as follows:

> The lack of competent instructors to take charge of outlying section bases and carry on the instruction, and also the impossibility of securing the necessary equipment for these small detached groups, have rendered a definite adherence to any prescribed routing of instructions absolutely impossible.

This and similar communications and reports of inspection emphasized the need of centralizing the training activities in the district, with the result that the following camps were constructed:

Pelham Bay Park, N. Y.—About June 15, 1917, it was estimated that a minimum of 7,215 men would be required for duty afloat in district vessels. This took no account of the district shore personnel, nor of the men who might have to be trained in this district for general service. From every point of view it was evident that increased training facilities had to be provided at once, and subsequent to a conference between the Chief of the Bureau of Navigation and the district commandant, together with an inspection of sites under consideration, the Bureau of Navigation requested on June 25, 1917, that the Bureau of Yards and Docks proceed with the erection of a training camp for 5,000 men at Pelham Bay Park, N. Y. Plans and specifications were prepared and consent of the owners of the property (the city of New York) was secured. A contract was awarded, and actual construction began about the 1st of August. The construction had advanced sufficiently by the first week in October to permit training of a limited number; the formal commission followed on November 7, with facilities available for a full complement of 5,000 men.

During September it became apparent that there would be need for eventual expansion of the camp, when the Bureau of Yards and Docks received the following letter:

NAVY DEPARTMENT, BUREAU OF NAVIGATION,
Washington, D. C., January 24, 1918.

To: Bureau of Yards and Docks.
Subject: Pelham Bay barracks, increased facilities.

1. It has been definitely decided that the Navy will be required to man all ships chartered by the Army as troop, animal, or cargo transports.

2. Demands for manning large numbers of each type of vessels have been received with practically no warning, and are taxing the Navy's facilities for supplying trained men. It is evident that further demands may confidently be expected, also with little or no warning, and it is now beyond question that a very considerable increase in facilities for training the crews is an immediate and urgent need.

3. Some 75 per cent of the transport vessels are expected to fit out in New York. Owing to the suddenness of the demands to take over the vessels, the training and depot facilities must be at that place if the Navy is to respond efficiently to these demands.

4. The cheapest method of meeting these demands will be to expand on existing station, as some of the existing facilities will not need to be duplicated. Operating overhead charges will also be much less if an existing station is expanded in lieu of starting an additional one.

5. It is requested that the Bureau of Yards and Docks at once undertake to secure from the authorities of New York City nominal lease of additional land at Pelham Bay Park, contiguous to the land now occupied by the naval training camp, and provide training facilities for 10,000 additional men; it is desired that about 20 per cent of these facilities constitute an isolation unit.

L. C. PALMER.

Approved:
JOSEPHUS DANIELS,
Secretary of the Navy.

The consent of the city authorities was not received until the last of February, 1918, and the construction of the camp on a day-labor basis was begun under the supervision of an officer of the Corps of Civil Engineers. Completion on August 1 was contemplated, but as a matter of fact the incoming detention for 2,000 men was completed on June 1, and began the training of recruits immediately. The main camp for 8,000 men was ready for occupany on July 1, 1918, and thus, with the hospital facilities which were finished a little later, the total capacity of 15,500 was reached.

Particulars of the execution of the Pelham extension are here inserted from the personal account of the officer in charge, Commander E. C. Brown (C. E. C.), U. S. N. R. F. (inactive):

It was perfectly apparent from the outset that the prosecution of this job at the rate required would only be hampered by the intervention of a contractor. Authority to hire labor without reference to civil service laws was obtained from the President, and authority to purchase in advance of requisition was obtained from the Bureau of Supplies and Accounts.

Offices were opened at 101 Park Avenue, New York City, on the 21st of February, with no organization. On the 1st of March purchasing, traffic, accounting, estimating, drafting, engineering, and other departments were completely organized, as well as the entire field force, which was under the supervision of Mr. W. S. Faddis, who consented to act as general superintendent in the field, with the consent of his company.

Besides proper organization, some other innovations were introduced in the building of this camp, aiding materially in reducing its costs and expediting its completion. Two sawmills containing 20 saws of various types each were erected, and all material for the entire job was scheduled and cut in these mills. No other saw was allowed to be used on the work until boarding commenced. Each gang did its own work in rotation. The first gang dug the postholes and put in the concrete bottom; the second gang placed foundation posts, sills, and floor beams; a third gang erected the stud walls and roof rafters; the next gang did the boarding and put in the window frames.

Ground for the isolation camp was broken on March 15, and 88 buildings were completely framed on March 29, after a total of 88 working hours. It is interesting to note that although this camp was built in less time than any other of the same size, there was no overtime. The isolation camp was occupied on June 1, and the entire camp July 1. The formal flag raising took place July 4, when the Secretary of the Navy made the dedicatory address. The hospital was completed on the 1st of August.

It is interesting to note that in all of this work only two items were sublet: (1) A radial brick chimney, and (2) a small amount of pile driving. All other work, including lighting, heating, and plumbing, was done by the organization of the officer in charge. The heating work was most successful on account of the excellent design of Mr. Henry C. Meyer, jr., a consulting mechanical engineer of New York City. Many innovations were introduced in the electrical work, such as the assembling and reeling of distribution wires in the shop. When a building was to be wired, after the collar beams were in, this reel would be dragged over the top of the collar beams, all of the laterals falling into their proper places. In this way one electrician and one helper completely wired the building in one hour. The excellent installation resulting proved later by actual test to give twice the light with one-half the wattage used in some regular electric layouts in other camps. Credit for the success of this part of the work should be given to Mr. Bassett Jones, a consulting electrical engineer of New York.

The most interesting thing about this proposition, which was the only large camp built without a contract, is that it was possible to get the best talent to step into the various branches of the organization. Due credit must be given to the following men, in addition to those above mentioned:

Mr. George H. Creasy, who gave up a large private business to act as plumbing superintendent; Mr. Albin Gustafson, who gave up his private business to act as electrical superintendent; Mr. K. G. Smith, a civil engineer, who gave up his private work to act as office manager.

The cost of the Pelham operation done directly without contractors was 18 cents a cubic foot, including concrete roads, heating, lighting, plumbing, sewage disposal, piers, coal-conveying apparatus, power house, and everything complete.

A system of ventilation was used throughout in the design of Pelham, in which, by boxing two of the floor beams, air was carried in from the outside under the radiators placed centrally, and out through holes in the ceiling through suction-draft ventilators. On actual test the air in each building with all windows and doors closed was completely changed six times in an hour.

Twenty million board feet of lumber, mostly spruce, was landed on the job in eight weeks. None of the lumber ordered through governmental agencies arrived until six weeks afterwards, when the camp was practically completed.

City Park, Brooklyn, N. Y.—As previously stated, men mobilized at New York were being quartered in various vessels. Needless to say, such accommodations were but a poor makeshift. Repairs and alterations, which were going on day and night in the fitting of the vessels for service, made living conditions aboard about as bad as could be, to say nothing of the interference which the presence of this personnel no doubt offered in the prosecution of such repairs.

Late in June the commandant reported having secured from the city authorities the free use of a small public park just outside the navy-yard wall. The Bureau of Yards and Docks was requested to undertake the construction of a receiving-ship barracks of a capacity as great as this plot of land would allow.

In spite of the somewhat indefinite nomenclature which the pressure of war imposed on the training establishments, it is well at this point to set forth clearly the central intention of a receiving-ship camp. Such camps were situated near or at ports and bases, and replaced the actual receiving ships as the latter were outgrown or pressed into service. Primarily, then, these camps were reservoirs or clearing houses for already trained personnel awaiting assignment to vessels, and the training features were made secondary to urgently required barrack and messing facilities. Such a notion is to be conveyed in general whenever the term "receiving-ship camp" is used.

The third naval district, with New York as its headquarters, was naturally swarming with the new naval personnel before the war had been many weeks in progress. Mobilized from all sources, fed in through the training-camp and naval militia systems, they were passing through in a swelling stream to their manifold war assignments—particularly in the opening period as armed guards for merchant vessels.

Hence the insistent demand for receiving-ship quarters ashore, and the City Park camp met a most vital need as a clearing station for the armed guard.

Particulars of the remarkable progress made in the construction of this camp for 3,000 men are herewith abstracted from the personal account of the officer in charge of construction, Commander E. C. Brown, who also conducted the Pelham Park extension operation above noted:

The tentative plot plan layout was verbally approved by the Chief of the Bureau of Yards and Docks on June 28, 1917. The working plans were started June 29, and including lighting, heating, and plumbing, were completed five days later, July 3, and submitted to the bureau for approval July 4. Ground was broken on July 5 and work started on July 6 by the general contractors.

The original plans were carried out with the exception of the mess hall, which was changed to the stand-up cafeteria system upon advice being received that more than the 3,000 men who were to be housed in the park camp would have to be messed there. The installation provided has operated with eminent success. It necessitated enlarging the messing facilities somewhat and caused some delay in the starting of this building, but the building was completed with the rest of the camp. The construction work was practically completed on August 4, and from that date until August 18 all equipment was installed. All of this equipment was purchased through the public works officer with the exception of the mess gear.

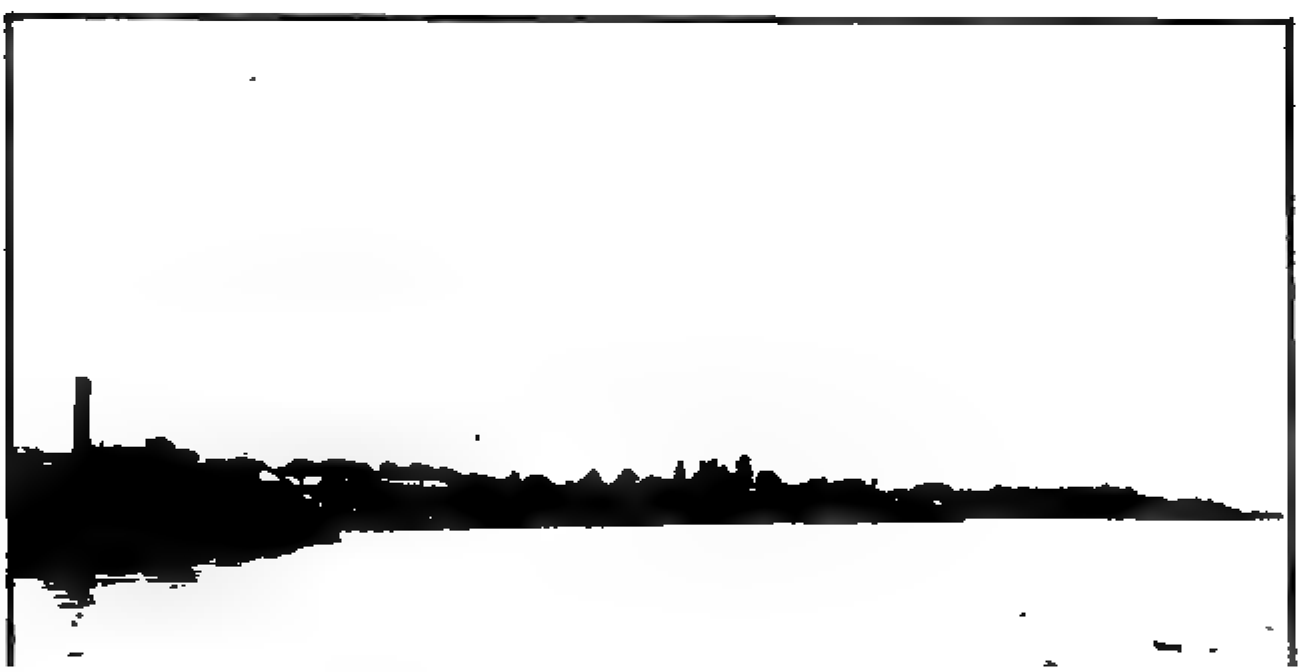
On August 10, the date originally promised by the public works officer, the men moved into the camp—the first meal served being breakfast, August 11, at which time 6,800 men were served in 45 minutes. Housing facilities were provided for 3,000 enlisted men, and approximately 20,000 meals per day were served. The average time required to serve one meal for 6,300 men on the continuous system was about one hour.

The cost of the camp was slightly under $400,000, including double-deck pipe rail bunks, bunk bottoms, concrete roads and walks, lighting, heating, plumbing, refrigerators, ranges, kettles, bake ovens, tables, furniture, and all equipment with the exception of mess gear. On the basis of 3,000 men housed and 6,000 men subsisted, the camp represents an average from a cost standpoint of 4,000 men, making the individual price of the camp, complete, $100 per man. This price includes the buildings which were added to the original layout, namely, hospital, dispensary, canteen, and administration building, and offices for chaplains and armed guards.

It will be noted from the foregoing that all the men quartered at the navy yard were messed at City Park, but all in excess of 3,000 continued to sleep aboard the ships being repaired. Later, however, in order that the sanitary requirements of the Bureau of Medicine and Surgery might be observed, the capacity of City Park was fixed at 2,500 men.

Ellis Island.—Reports dated August 10 and September 10, 1917, indicate a receiving-ship personnel present in the navy yard of 4,800 and 6,300, respectively. These men in excess of the 2,500 provided for at City Park were quartered on the various ships at the yard, but with the commissioning of some of these vessels the need for additional quarters became apparent. An excursion steamer, the *Adirondack*, was leased for the purpose of housing 1,000 men, but was found to be totally unsuited for the purpose. The sanitary conditions on these ships were entirely unsatisfactory, and it is said that the young men who came to them from civil life formed a most erroneous idea of the naval service, and these ideas became more or less public and did the service considerable harm. Meanwhile, the armed guard was crowded in City Park beyond safe health conditions. Pelham was turning out personnel to man not only the Navy but also Shipping Board vessels. Thus the housing of "general detail" men was becoming a serious problem.

General view, Armed-Guard Camp, City Park, Brooklyn, N. Y



General view, Receiving Ship Barracks, Bay Ridge (Brooklyn), N Y

Ellis Island was particularly well located, and its facilities were excellent for this use, besides being ready; but it was only after considerable correspondence that the Department of Labor turned over for the joint use of the Army and Navy accommodations for 3,500 men, in which quarters the Navy finally secured space for 2,000. The first draft arriving on February 2, 1918, began equipping and completing arrangements for successive drafts, until by April 1,000 men were quartered; and not long afterward the full 2,000 were accommodated. This station remained in commission as a part of the receiving ship at New York until the end of hostilities.

Receiving Ship, Bay Ridge, Brooklyn, N. Y.—The agreement with the owners of the *Adirondack* and *Morse* excursion steamers used as part of the receiving ship, in addition to the undesirable features previously mentioned, required the early return of these ships to the owners. To meet this situation, a conference was held, at which several methods of possible solution were discussed. Meanwhile it had become necessary to transfer men from the receiving ship to Bensonhurst.

Upon the recommendation of the commandant, permission was obtained from the city authorities to occupy a portion of the parkway of the shore drive known as Bay Ridge Boulevard, Brooklyn, N. Y. On April 18, 1918, the Bureau of Navigation requested the Bureau of Yards and Docks, following the Secretary's approval, to proceed with the erection of barracks for 5,000 men on this site. This request was canceled, however, and some delay occurred while consideration was being given an alternative proposition. The project was a little later reauthorized, and bids were opened July 15, 1918, followed by an award of contract. The first men were quartered late in October, and additional transfers were made as fast as buildings were completed; but the new cantonment was not finished in time to be of much use as a receiving ship during the period of hostilities. However, it was particularly valuable during the demobilization period.

Some conception of the necessity of receiving-ship barracks at New York can be gleaned from the fact that approximately 182,000 naval ratings passed through the port, notwithstanding the difficulties encountered, and between August, 1917, and March, 1919, as many as 1,300 were handled in one day.

Steam Engineering School, Stevens Institute, Hoboken, N. J.—On February 27, 1918, the president of Stevens Institute of Technology, Hoboken, N. J., addressed a letter to the department confirming a tentative agreement which had been made for placing the institute at the disposal of the Navy for the period of the war. The burden of providing crews for the Emergency Fleet vessels then under con-

struction required also the instruction of apt men as officers. The officer material schools were then in full operation, and Stevens Institute afforded especial opportunity to give instruction to engineering classes. The school started in March with a small class, but the accommodations for housing and keeping the men under military control were poor. It finally became necessary to build quarters and a three-story brick building for 300 men. These, together with a temporary mess hall and cooks' barracks. were erected on the institute campus, the work being completed about May, 1918.

Steam Engineering School, Stevens Institute, Hoboken, N. J.

FOURTH NAVAL DISTRICT.

Philadelphia, Pa.—Prior to March 1, 1917, the receiving-ship offices at Philadelphia occupied three or four small rooms in a navy-yard building, and the men were quartered in vessels moored at the yard. When war was declared men began to arrive in such large numbers that existing accommodations were immediately crowded. In addition to recruits, this station began to receive the naval militia from several States, for which it had been designated as the rendezvous. These men were quartered on all available ships, including one or two ex-German merchant-type cruisers interned there. However, the necessity for quarters ashore was soon recognized, and on April 25 the Bureau of Yards and Docks was requested to erect barracks for 5,000 men. The site selected was on the east end of League

Emergency barracks for recruits, Navy Yard, Philadelphia, Pa.

Interior view of quarters, Wissahickon Barracks, Cape May, N. J

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Island, and work was begun on May 1, 1917. By the middle of July enough buildings were completed to permit the housing of a limited number of men. By the end of that month there were 1,800 in camp, and by early winter the full complement of 5,000 had been reached. The medical authorities reported the camp overcrowded, and the normal capacity was then reduced by about 20 per cent. The existing seamen's barracks was overhauled and made habitable for about 300, and a tent camp was maintained for 500 men when weather permitted. This camp was functioning not only as a receiving ship but as a training camp in addition, and its war-time history is one of almost continuous congestion. Early in the spring of 1918 it had become entirely inadequate; and on March 15, 1918, the Bureau of Navigation wrote the Bureau of Yards and Docks requesting that it undertake the construction of additional barracks and facilities, which, when completed in November, provided a total capacity, exclusive of tents, of 6,400.

Wissahickon Barracks, Cape May, N. J.—On May 28, 1917, an allotment was authorized for the construction of a naval training camp for the fourth naval district, and after consideration of many possible sites an agreement was made on June 14 for the use of a farm at Cape May, N. J. On June 16 the Bureau of Yards and Docks placed a contract for the necessary construction to accommodate 2,000 men. The city of Cape May laid mains and furnished water for the cost of pumping and permitted the use of their sewers without charge. On August 7 this camp, known as Wissahickon Barracks, was ready for operation, but as constructed it was already inadequate for district needs. Indeed, it became necessary to send several thousand fourth-district men to Great Lakes and other stations to meet the conditions.

Only one extension to Wissahickon was ever built, and that was a 500-man detention camp, which was authorized in June, 1918, and which was about completed at the time of the armistice. Another extension of the camp was authorized in September, 1918, which would have increased the total capacity to 6,500 men. Plans and specifications were prepared and ready for release to bidders on the date of the armistice, which stopped the project altogether.

Cooking School, Naval Home, Philadelphia, Pa.—Prior to the war cooking schools had been maintained in the permanent stations at Newport and San Francisco, but these had only a limited capacity. With the advent of war the necessity of providing cooks, not only for vessels, but also for camps and other shore stations, was first met by the enlistment of men who had practiced allied occupations in civil life. To meet the rapid growth of the Navy, however, it became necessary to instruct men in the culinary art at schools established

in the various districts. In general, such a school was operated as an adjunct to a camp, but in the fourth district a cooking school was established at the Naval Home, employing the existing galley for practice purposes and accommodating the men in tents heated with oil stoves. In the summer of 1918, when the Shipping Board requested the Navy to man their vessels, this school was extended, and barracks and instruction buildings were erected which were reported to represent the finest equipment and best planned cooking school in the country. In the galley cooking appliances which were especially adapted to instruction, such as glass-front ovens, etc., were installed, and an elevated platform facilitated the observation of galley activities by the class under instruction.

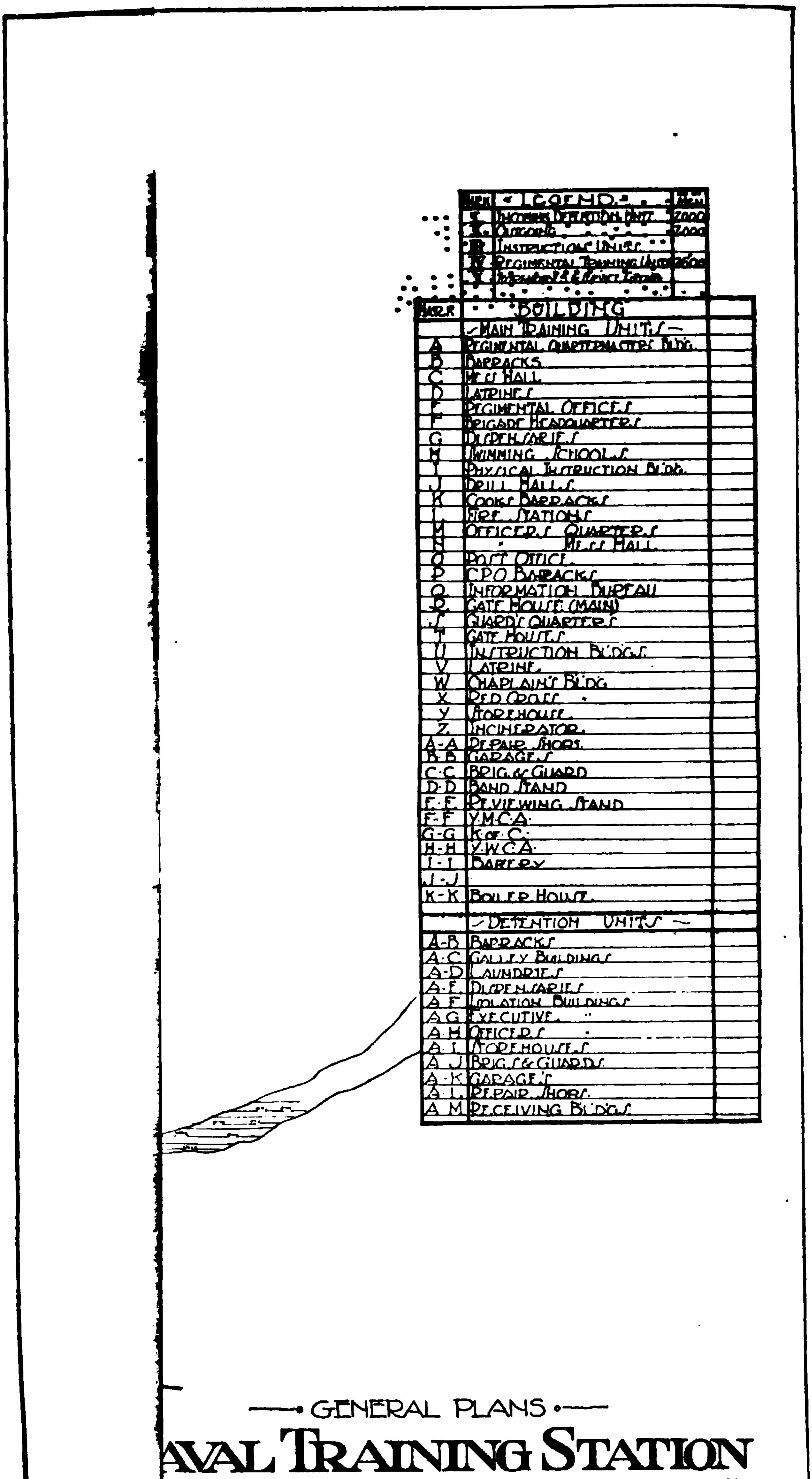
FIFTH NAVAL DISTRICT.

Norfolk, Va.—The naval training station, Norfolk, known as St. Helena, was established in 1908 on a site along the Elizabeth River, just opposite the navy yard. The commanding officer of the training station was also in command of the receiving ship at Norfolk, which, in addition to the old warships *Richmond* and *Cumberland*, comprised also a considerable camp on shore when the war began. Thus, both physically and administratively, the receiving ship and the training station were very closely allied. The original training station had grown from its original capacity until at the beginning of the war, including the receiving ship and its facilities, it had a total capacity of 3,555 men. With the declaration of war men began to pour in rapidly, and at first the overflow were sheltered in tents. This station had, however, developed a small bungalow type to house 10 men, and it was found that a tent for 3 men occupied nearly as much space as one of these structures. The bungalow was already standardized, and was of such simple construction that it could be readily erected in quantities by station labor, and most important of all, it was more suitable for the winter weather in that climate. Before the winter of 1917 had set in, sufficient bungalows had been completed to raise the total capacity of the station to 7,679. The requirements of the Bureau of Medicine and Surgery, set forth in previous connections, subsequently reduced the capacity to 4,254 men. This camp was abandoned when the naval operating base at Hampton Roads became available, the site being designated as an annex to the navy yard.

Naval Operating Base, Hampton Roads, Va.—A detailed account of the development of this base in its various phases is given elsewhere in this volume. Only a summary of the training facilities provided will be attempted here.

An act of Congress, approved June 15, 1917, authorized the President to commandeer the tract of land, with all appurtenances thereto, which had been the site of the Jamestown Exposition. The total tract taken over was 443 acres, of which 268 were assigned to the training station. The congested condition at St. Helena emphasized the necessity of additional training facilities in the vicinity of this important port. Plans had been prepared which, with very minor subsequent additions for special purposes, provided for a capacity of 13,500 men. Construction was begun as soon as possible, and on October 12, 1917, a little less than four months from the date of approval of the act of authorization, it was reported that one regiment from St. Helena had been moved to the naval operating base, with appropriate ceremonies. From this date the population of the station increased rapidly. New regimental units were being completed and turned over to the commandant every week or two. It was not until April, 1918, however, that the training station at St. Helena was completely superseded by Hampton Roads, as the former had to be used for some time as an outfitting station or incoming detention camp. From a complement of 1,669 on October 17, 1917, the new station (Hampton Roads) had increased to a total of 12,693 on November 27, 1918.

In connection with the construction of the training station at Hampton Roads, an item deserving of special mention is the electrical and general school buildings erected. These semi-permanent structures—mill construction with brick veneer—were originated through the necessity for an electrical school. The electrical school was first designed with special facilities for the purpose, the general school being a reproduction in exterior appearance, but in interior arrangement providing only the facilities of a modern school building. The construction of the electrical school was an outgrowth of the congestion existing at New York, this institution having first been housed at Pratt Institute. The building as designed for Hampton Roads provided for the operation of boilers by a student class, the steam produced being utilized in generators used for demonstration before another class. The current thus produced was distributed throughout the building and was utilized for the benefit of classes being instructed in the operation of various electrical appliances. Rooms were also provided with special ventilation to facilitate the study of storage batteries and gas engines. Later an especially interesting adjunct to the electrical school was constructed, this being a device known as the "*U. S. S. Electrician*," which was, within the practical limits of land structures, a battleship, especially so far as related to the electrical installation involved. Besides classrooms, there were installed in this school building many of the electrical appliances



MRK	LEGEND	MEN
I	INCOMING DETENTION UNIT	2000
II	OUTGOING	2000
III	INSTRUCTION UNITS	
IV	REGIMENTAL TRAINING UNIT	2600
V	[illegible]	

MARK	BUILDING	
	— MAIN TRAINING UNITS —	
A	REGIMENTAL QUARTERMASTERS BLDG.	
B	BARRACKS	
C	MESS HALL	
D	LATRINES	
E	REGIMENTAL OFFICES	
F	BRIGADE HEADQUARTERS	
G	DISPENSARIES	
H	SWIMMING SCHOOLS	
I	PHYSICAL INSTRUCTION BLDG.	
J	DRILL HALLS	
K	COOKS BARRACKS	
L	FIRE STATIONS	
M	OFFICERS QUARTERS	
N	" MESS HALL	
O	POST OFFICE	
P	CPO BARRACKS	
Q	INFORMATION BUREAU	
R	GATE HOUSE (MAIN)	
S	GUARDS QUARTERS	
T	GATE HOUSES	
U	INSTRUCTION BLDGS.	
V	LATRINE	
W	CHAPLAIN'S BLDG	
X	RED CROSS	
Y	STOREHOUSE	
Z	INCINERATOR	
A-A	REPAIR SHOPS	
B-B	GARAGES	
C-C	BRIG & GUARD	
D-D	BAND STAND	
E-E	REVIEWING STAND	
F-F	Y.M.C.A.	
G-G	K of C.	
H-H	Y.W.C.A.	
I-I	BARBERY	
J-J		
K-K	BOILER HOUSE	
	— DETENTION UNITS —	
A-B	BARRACKS	
A-C	GALLEY BUILDINGS	
A-D	LAUNDRIES	
A-E	DISPENSARIES	
A-F	ISOLATION BUILDINGS	
A-G	EXECUTIVE "	
A-H	OFFICERS "	
A-I	STOREHOUSES	
A-J	BRIGS & GUARDS	
A-K	GARAGES	
A-L	REPAIR SHOPS	
A-M	RECEIVING BLDGS.	

— GENERAL PLANS —

[N]AVAL TRAINING STATION

EASTERN EXTENSION HAMPTON ROADS #

87022—21. (To face page 66.)

Barrack group, East Camp, Hampton Roads, Va.

Typical barracks, East Camp, Hampton Roads, Va.

Laundry and galley, East Camp, Hampton Roads, Va.

Post office, East Camp, Hampton Roads, Va.

used on shipboard, such as searchlights, signals, cranes, and turret moving and ventilating devices, so that opportunity might be afforded to demonstrate the practical use of such apparatus.

East Camp, Hampton Roads.—Upon receipt of information in July, 1918, that the United States Shipping Board would call upon the Navy for approximately 200,000 trained men for the ships to be completed before January 1, 1920, an estimate of the situation indicated that the Navy's total existing housing and training facilities must be increased at once by approximately 30,000 men. About one-half of this number were provided for at the naval training station, Newport (Coddington Point), as hereinbefore discussed, and it was considered that the remainder should be cared for in the vicinity of Hampton Roads. After consideration of the available sites, one at Yorktown, Va., was selected, and a complete camp with all facilities for 14,000 men, together with an 800-bed hospital and accommodations for a hospital personnel of 400, was designed. Bids were to be opened September 9, 1918, but further consideration led to the cancellation of this project in favor of an equivalent camp to be erected on a tract of about 370 acres across Boush Creek, opposite the training station, Hampton Roads, and subsequently known as "east camp" site. Work was promptly undertaken on this location. The proximity of the new camp to the naval operating base eliminated the necessity of separate administration, and thus several of the camp buildings were omitted, as was the entire hospital portion of the project. The signing of the armistice arrested this project before the barracks were ready for occupancy. The work was well under way, however, and the camp was finally completed as contemplated; and being the last one that was designed and constructed, it had the benefit of the experience gained during the construction of the other stations. For that reason, it is to-day the best example of a naval training camp constructed during the war period.

Ensigns' School, Annapolis, Md.—At the outbreak of hostilities many men of education had enrolled as officers in the Naval Reserve Force and many of them, especially former members of the United States Power-boat Squadron, had had prewar training in the duties of officers. There had also been one or more summer cruises aboard the ships of the battle fleet by civilians, the so-called "naval Plattsburg." It was realized, however, that further instruction was necessary before such men could be assigned to positions of responsibility under war conditions. The establishment of the district officer material schools at the various stations was one step toward the solution of the problem, while another was a plan formulated late in May, 1917, to utilize during the summer the space vacated by the graduating class of the United States Naval Academy, together with

the academy organization and equipment, for a short intensive course for such partially trained officer personnel. On June 6, the initial class of about 200 were assigned quarters in Bancroft Hall, which had been vacated by the graduating class. They were given a course of about 10 weeks, the results of which were so gratifying that it was decided to continue the plan. As the existing accommodations were filled by midshipmen of the new class, it was necessary to build barracks and increase the staff of instructors. Temporary barracks for 300 student officers were erected, and the second class reported on October 10, 1917. The course was then extended to 16 weeks, and a further increase was made by erection of a barracks and mess hall for 150 men, which was completed in four weeks. Thus a school having a capacity of 450, which was augmented during the summer by use of the vacant rooms in Bancroft Hall, was completed to remain in operation throughout the period of hostilities.

Marine Camp, Quantico, Va.—This important project is discussed in the chapter devoted to construction for the Marine Corps.

SIXTH NAVAL DISTRICT.

Charleston, S. C.—Mobilization of reserves and volunteers at the navy yard, Charleston, S. C., so overcrowded the existing receiving ship (U. S. S. *Hartford*) and other available accommodations that a small tent camp was pitched early in 1917 to accommodate the overflow. More habitable structures were required, however, and on April 26, 1917, an allotment was telegraphed which authorized the construction of a camp for 1,000 men, work to be done by yard labor, assisted by enlisted men. These buildings, designed locally, were of a semibungalow type, intended to accommodate 25 men each, so constructed as to admit a maximum of light and air in good weather, and capable of being closed with canvas curtains in inclement weather or heated by trash stoves in cold weather.

About this time, the authorities of the city of Charleston tendered the free use of land just outside the navy-yard boundary and adjacent to the 1,000-man camp then under construction. Accommodations at all camps were so seriously overcrowded that it was decided to accept this offer and utilize it for the expansion necessary. Accordingly, on May 3, 1917, the Bureau of Yards and Docks was requested to proceed with construction to increase the facilities so as to care for a total of 5,000 men, including certain additional construction for the 1,000-man camp previously authorized.

Ground was broken on the 1,000-man portion within the yard on April 30, and the work was completed on June 8. At this time about 735 men were under training, in addition to the personnel quartered on the *Hartford*. On this date (June 8) the contract-built portion

Drill hall at East Camp, Hampton Roads, Va.

Boiler plant, East Camp, Hampton Roads, Va.

Typical barrack, Naval Training Camp, Charleston, S. C.

General view, Naval Training Camp, Charleston, S. C.

for 4,000 men on city property was about 50 per cent completed, but the delay in getting equipment nullified to a great extent the immediate benefit of this construction. A sanitary survey by the Bureau of Medicine and Surgery resulted in the application of the strict specifications for sleeping quarters, i. e., 450 cubic feet of air space per man, with not less than 5 feet between heads of sleeping men. As these barracks had but 220 cubic feet of air space on a 5,000-man basis, the capacity of the camp was reduced to 2,500 men. It was the original intention to use the camp to train naval reserve forces, and no detention camp was provided; the almost continuous outbreak of contagion, however, necessitated the establishment of a tent detention camp. The latter on April 16, 1918, was ordered to be replaced by standard detention-camp barracks for 600 men. This, together with the new barracks which had been constructed meantime for the machinist's mate school, soon provided a total capacity (exclusive of tents) for 3,500 men under training.

Marine Barracks, Parris Island, S. C.—This work was carried along with other emergency camp construction, but a discussion of it will be found in the chapter on Marine Corps projects.

SEVENTH NAVAL DISTRICT.

Key West, Fla.—Early in the period of hostilities the commandant leased at small cost the P. & O. steamship wharf at Key West, with its covered sheds and adjacent land, as a site for mobilizing and training such men as might be enrolled there. On June 1, 1917, the Bureau of Navigation requested Yards and Docks to increase the capacity to a total of 1,000 men by the erection of barracks, a galley and mess hall, etc. This camp was probably the cheapest erected during the war, and no attempt was made to secure a desirable plan, it being only possible, after utilizing the existing sheds, to erect structures of odd shapes and sizes on the available spaces adjacent. It is interesting to note that, notwithstanding these conditions, records indicate that finished training was given some 2,400 men, and partial training to about an equal number of others. Capt. Bennett, in commenting on this station in his "History of Work of the Training Division," writes in part as follows:

> Perhaps the most remarkable feature of all was the health conditions which prevailed. Only two deaths occurred at the camp, one of which was a drowning accident. The camp bore its share of the influenza epidemic, but in a total of 464 cases every one recovered. The epidemic was so severe among the civilian population that the camp furnished personnel for operating the city gas works, to assist in the work of the city's post office, and in compounding prescriptions in the drug stores of the city, which had been wholly unable to meet the demands incident to the epidemic.

EIGHTH NAVAL DISTRICT.

New Orleans, La.—The mobilization center for the eighth naval district was the naval station, New Orleans, where the seaman barracks was used for habitation until the requirements of war necessitated, late in April, 1917, the establishment of a tent camp. Conditions in this district were typical of those prevailing generally, although the immediate consequences were much less serious on the south and west coasts than in those districts bordering on the Atlantic—the latter being required to effect a large-scale coast-defense system immediately. Congestion in the northern training centers caused the transfer of many men to the southern districts, where greater facilities were immediately available. The tent camp at New Orleans provided for 1,000 men, and although the commandant during the summer of 1917 urged that it be replaced by wooden barracks before the hurricane season, the Bureau of Navigation decided against the recommendation. The tent camp was never completely replaced by wooden construction, though two barrack buildings with a maximum capacity of 116 men each were built by enlisted labor and a latrine for their inhabitants was built by station labor during the fall of 1917.

During July, 1917, the commandant recommended the establishment of a camp annex at West End Park, which had been tendered free of charge by the city authorities. Here boat exercises and small-arms firing, which were impossible at the yard, could be conducted. A wooden cantonment for 250 men was authorized on this site, it being the plan to detail successive drafts from the yard camp for a few weeks' practice in the desired exercises. Later, when the requirements of Medicine and Surgery made it necessary to reduce the capacity of this camp, additional barracks and service buildings were erected so as to increase the capacity of the camp to about 500 men.

Gulfport, Miss.—Accommodations at the training stations, as soon as established, were always one or more laps behind in the race with required capacities; and in an effort to cope with the situation, new and distinct locations were selected as temporary expedients. Such camps, however, expanded beyond early intentions and finally were looked upon as permanent for the period of the war. One of the early emergency locations selected was that of the Mississippi Centennial Exposition grounds at Gulfport, Miss., the inauguration of the exposition having been indefinitely postponed on account of the war. The exposition buildings, which were nearing completion, were utilized as far as possible, and these, with a considerable amount of auxiliary construction, provided a truly efficient camp for 2,000 men. Construction work began on November 25, 1917, and notwithstand-

ing additions authorized from time to time, the camp was commissioned about the middle of April, 1918.

Pensacola, Fla.—While training was actually carried on at Pensacola, it was of a special type—aviation—and further reference to the bureau's activities at this station will be found in another chapter.

NINTH NAVAL DISTRICT.

Great Lakes, Ill.—As previously stated, Great Lakes was the largest of the four permanent training stations existing prior to the war. This station had a capacity of 3,000 men, and occupied a tract of 167 acres located about 33 miles north of Chicago and overlooking Lake Michigan. Increased recruiting began in this district as early as October, 1916. An average of 191 men monthly were received at the station during the first three quarters of 1916. From that time on, the average steadily increased until in March, 1917, 1,364 new recruits arrived, and in April 9,027. A large proportion of these men were quartered in tents, while others were examined, outfitted, and sent to other stations after only a few days at Great Lakes. A detailed account of the growth of the station's housing facilities is quite impossible within the limits assigned, covering as it would the entire period of hostilities.

The use of tents could obviously not be continued because of the winter climate of this region, but before other quarters could be provided a colony of more than 5,000 tents was in operation, the men being accommodated in a comparatively primitive manner. In order to eliminate these conditions it became necessary to secure more ground, and after a full discussion it was decided to adopt at Great Lakes a regimental unit system of expansion, each unit providing for about 1,728 men. These regiments were then to be grouped into camps, the size and location of which were determined by the topography of the available land as well as by the military necessity.

On October 11, 1918, the station occupied more than 1,200 acres and comprised about 775 buildings. Without recounting in detail the history of each addition necessitated as the war went on, it may be recorded that the following camps were finally provided, the main station and Camp Barry being the only ones existing prior to the war, and the latter only in the sense that it was erected upon the original 167-acre tract:

Regiment.	Camp.	Purpose.
First	Camp Perry	Recruit training.
Second	do	Do.
Third	do	Do.
Fourth	do	Do.
Fifth	Camp Dewey	Do.
Sixth	do	Hospital corps and yeoman schools.
Seventh	do	Radio school.
Eighth	Camp Decatur	Incoming detention.
Ninth	Camp Farragut	Do.
Tenth	Camp Ross	Main hospital.
Eleventh	Main station	Schools.
Twelfth	Camp Paul Jones	Public works division.
Thirteenth	do	Ship's company.
Fourteenth	Camp Barry	Incoming detention.
Fifteenth	Aviation Unit	Aviation schools.
Sixteenth	Camp Luce	Outgoing detention.
Seventeenth	do	Do.
Eighteenth	do	Outgoing detention and public works.
Nineteenth	Camp Lawrence	Recruit training.
Twentieth	do	Do.
Twenty-first	do	Do.
Twenty-second	do	S. A. E. Officer-material school.

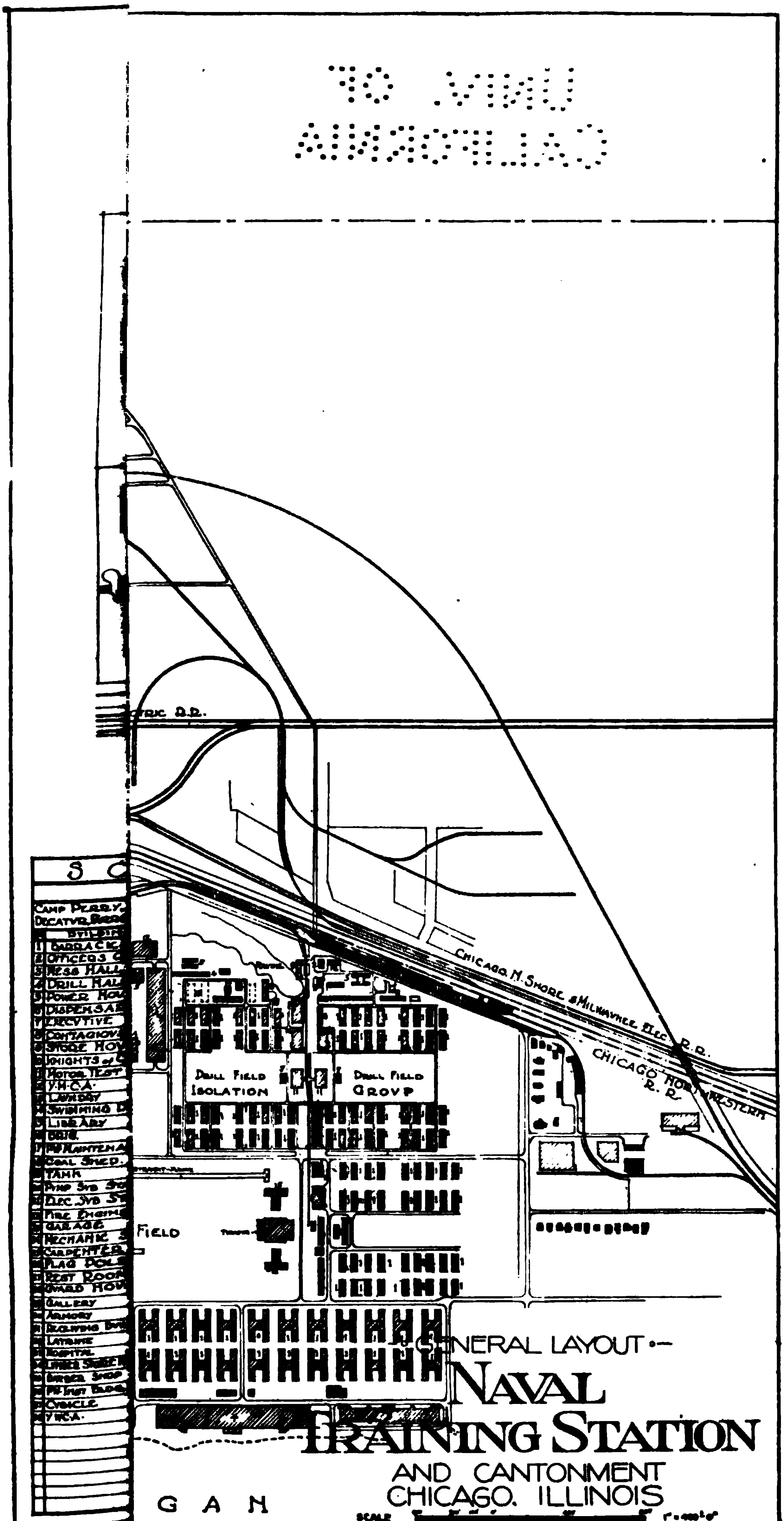
The capacities of these camps varied with their types and uses, but the following excerpt from a letter of the commandant, Capt. W. A. Moffett, United States Navy, under date of August 28, 1918, will serve to illustrate the strides being made to complete by fall a capacity to accommodate, in round numbers, 50,000 men:

> I am inclosing data giving the capacity of the station. You will note that the "safe" winter capacity is 44,754 on a basis of 450 cubic feet per man, and that the summer capacity is 52,317. Fifty-two thousand three hundred and seventeen does not include men in tents. We have 17,000 men in tents, which means that next summer we could house comfortably 70,000 men. In regard to the safe winter capacity of 44,754, I will say that you can safely count on a practically safe capacity of 50,000 men. If necessary, we can put a couple of thousand men in each of the drill halls and in other places. I would also say that if the necessity arises I would not hesitate to take 60,000 men during the winter.

The total cost of the expansion accomplished at Great Lakes under all contracts let during the emergency period was approximately $17,127,000. The reader will note the contrast between this figure for one station and the $1,500,000 at first contemplated as the total which would be required for all stations.

For a closer study of the organization which handled the immense development of Great Lakes and of the results accomplished, reference is made to two articles at the end of the present chapter, contributed by officers of the Corps of Civil Engineers who had successive local charge of the projects involved.

Training Camp, Detroit, Mich.—On February 7, 1918, the Bureau of Navigation wrote requesting Yards and Docks to provide, at the earliest possible date, barracks at the River Rouge plant of the Ford Automobile Co., Detroit, Mich., for selected portions of prospective crews who were to man the "Eagle" boats then under construction by the company. This request was given the Secretary's approval, limiting initial construction to a capacity of 1,000 men and 200 officers, two days later.



87022—21. (To face page 76.)

Plans were quickly prepared, and actual construction work on a site about 500 yards from the shipyard was begun on February 16, 1918. On May 31, 1918, the bureau was requested to add to the camp certain additional structures which would provide for special instruction in the operation of Eagle boat machinery, together with other facilities for administration.

A camp for 1,000 men and 200 training officers was constructed, provision being made for a possible future extension to the capacity originally desired. Work was completed on June 8, 1918, and the camp remained in operation until after the signing of the armistice.

ELEVENTH NAVAL DISTRICT.

Training Camp, San Diego, Calif.—The camp at San Diego, like Gulfport, was established temporarily to relieve overcrowding at other stations. Late in April the park commission of San Diego offered the free use of certain of the buildings in Balboa Park, which originally formed a part of the Panama-California Exposition. The overcrowding of the regular naval stations throughout the country caused the department after investigation to accept this offer. After some minor repairing and equipping, the first draft of 70 men was received May 20, 1917, and by June 6 provision had been made to accommodate 2,000 at each mess, so that the full capacity of 4,000 men could be subsisted in two shifts. The outbreak of contagion in July necessitated the establishment of a tent isolation camp of about 500 tents, which were sent by express from the nearest source of supply (New York City), with instructions to put all hands under canvas until the situation had improved. From then on Balboa Park became substantially a tent camp, although improvements to the buildings were made which ultimately provided for a total capacity of 5,000 men. The necessity for expanding this camp became apparent toward the end of the war period, and suitable sites for the erection of barracks were being investigated, which but for the signing of the armistice would probably have been erected on land adjacent to San Diego Bay.

Training Camp, San Pedro, Calif.—On June 6, 1917, it was reported that part of a pier and shed of concrete construction, located in San Pedro (Los Angeles Harbor), Calif., and capable of accommodating 1,000 men, was offered free for the period of the war. By the installation of equipment and minor improvements, such as plumbing and partitions, a camp was put in commission on June 11. Additional space was later secured, but as a part of the original was turned over to the submarine forces only about 1,200 men could be cared for at any time. Additional quarters for 2,400 men were provided in tents erected on land adjacent to the pier, of which a capacity of 800 was isolated for incoming detention purposes. On

this extension wooden structures used as mess houses, auxiliary buildings, and instruction halls were erected.

TWELFTH NAVAL DISTRICT.

Naval Training Station, San Francisco, Calif.—In 1898 a training station, the only one on the west coast, was established on a small island in San Francisco Bay known as Goat Island or Yerba Buena, of which 107.3 acres was devoted to the naval reservation. This site is by no means ideal for a training station because of the precipitous slopes to be found. For this reason serious difficulties were encountered in accomplishing the necessary war-time expansion. The existing main barracks consisted of a single story-and-a-half wooden building of inferior design and poor ventilation, but affording habitation for a maximum of 625 men. The only increase possible at this point would have been effected by tearing down this structure and erecting a two or three story building on the same site, and this was deemed unwise. The old Marine barracks some distance away was converted into a detention quarters, which, together with certain cabins adjacent thereto, was capable of housing about 240 men. By an ingenious arrangement of tents in terraces on the hillside, shelter was provided for the increasing war personnel. The improvised detention barracks (originally built for 80 Marines) was overcrowded and insanitary and soon proved entirely inadequate for the new demands. As soon as tents became available, this old building was abandoned as a barracks and utilized for kitchen, mess hall, offices, dispensary, etc. It became necessary to extend even the tent camps, and this was made possible only by the use of a part of the lighthouse reservation on the island. Latrines, washhouses, and a new galley designed for 5,000 men were erected near the old barracks, but winter conditions were not considered sufficiently severe at this point to justify the replacing of the tent camp with wooden barracks, especially in view of the topographical difficulties attending such construction.

Receiving Ship, Mare Island, Calif.—Early in April, 1917, the total estimated capacity for recruits received at Mare Island was only 600, to obtain which it was contemplated making use of the seamen's barracks and a ship moored at the yard. It was suggested that a portion of the then projected prison camp could be built which would provide for an additional 500 men. However, the Bureau of Navigation, in view of the conditions at San Francisco, felt that this capacity was too small, and on April 25, 1917, wired the yard to consider the erection of temporary barracks for 5,000 men. This was the inception of the training camp at Mare Island, which was afterwards designated as an annex to the receiving ship. It was not until September 1, 1917, that the receiving-ship establishment

was formally commissioned, the command including about 100 men on the U. S. S. *Intrepid*, a barracks building for 500 men, and the new camp, which by this date was practically completed. While this provided for a total of 5,600 men, the total capacity was reduced to 3,120 when the sanitary requirements of the Bureau of Medicine and Surgery were applied.

THIRTEENTH NAVAL DISTRICT.

Training Camp, Puget Sound Navy Yard.—Like all other naval districts, the thirteenth felt the need for additional accommodations at an early date. The Naval Militia of Oregon and Washington were mobilized at the Puget Sound yard, and added about 700 to their complement within about 10 days after war was declared. In addition, recruits were flowing in. On May 10, 1917, the commandant advised that 1,600 men were already assembled. These were being quartered aboard the U. S. S. *Philadelphia*, long used as a receiving ship at Puget Sound, and the U. S. S. *Boston*, which had been pressed into service to supplement the former. In addition, a tent camp was put in operation on May 15, and continued until October, when the occupants were transferred to wooden barracks. These wooden barracks were decided upon when the Bureau of Yards and Docks, on May 12, 1917, was requested to erect a camp for 5,000 men. The area selected offered difficulties to rapid construction, it being largely a wooded swamp. Enlisted forces were utilized for cutting trees, pulling stumps, and filling marshy areas, while the buildings were erected by station labor. Double-deck bunks were used in these barracks, and later, when Medicine and Surgery requirements were applied, the maximum capacity was reduced about 50 per cent. This reduction was compensated for by the establishment of a tent camp, heated by oil stoves, and by the remodeling of an old marine barracks, previously condemned.

Training Camp, Seattle, Wash.—The following information is presented from the personal account of the civil engineer officer then in charge of public works at Puget Sound, Capt. L. E. Gregory:

Early in June of 1917 it was decided that a training camp should be built on a portion of the grounds of the State University at Seattle for the purpose of training recruits for the Navy. The authorities in charge of this university, under the direction of Dr. Henry Suzzallo, were most enthusiastic in their desire to place at the disposal of the Government the facilities of the university, in order that they might be made of greatest use during the continuation of the war. As its location was immediately upon water which had a direct connection with the sea, it was natural that this institution should lean more strongly to the Navy, inasmuch as so many other universities throughout the country not so situated were in a position to give greater assistance to the Army. Arrangements having been made with the Navy Department for the construction of such a camp, plans were made early in June for a temporary tent camp for housing 500 men. As the location was such that yard labor was

not available, the work was placed under contract with a local concern on June 29, 1917, and Commander Miller Freeman, U. S. N. R. F., who had for several years been greatly interested in the State naval militia, was placed in command. Very quick work was done on this camp, for on July 27 an inspection was made preliminary to its being placed in actual commission.

Hardly had the camp been made ready for the 500 recruits from the State of Washington when it was decided to train an additional 500 men from Oregon, necessitating additional construction. Thereafter, the construction had to be augmented frequently on account of the constant increases in the number of recruits authorized for training. A very high class of men were obtained in this section, and advantage was taken of the university facilities for classroom work. This even extended to instruction in aviation, and an aviation school was one of the adjuncts of the camp toward its latter days. This addition was made possible through the generosity of Mr. Boeing, the head of the Boeing Airplane Factory in Seattle. He presented to the university much equipment for experimentation in aeronautic work, and this was of great value in training Navy recruits.

The capacity of the training camp was increased to such an extent that at the time of the signing of the armistice there were about 3,000 men under instruction therein.

THE COMPOSITE CAMP.

The idea of the " composite camp " is introduced as a conception unifying and correlating the diverse components of the emergency training system as treated individually in the foregoing. The thought of the camps as a composite is indeed not misleading, if consideration be given the relation the one station bore to another. One camp often centered about a special instruction school, and drew its students from the apt personnel of other camps. Some were used as general training centers, while others functioned as mobilization nuclei from which men were distributed to the various training camps, while still others operated as receiving ships or barracks for the armed guard or general detail, drawing their complement from the forces who had completed training at various points. The promiscuous use of the term " station " and " camp " may be confusing to those who were active in this branch of the naval service, for during the war the two terms took on distinct meanings, the latter indicating only those activities of a temporary nature, while the former designated one of the four original permanent locations and incident growth about them. Even this distinction does not entirely eliminate the composite camp, for all were organized and operating to the same end—to man the Navy—and with a view to picturing the growth of training facilities the accompanying cumulative curve has been prepared. This curve takes into account only completed work, both at the armistice and at other times. Work nearing completion at the armistice, if shown, would have indicated a higher maximum and a still more rapid rate of progress.

The reader must not reach the conclusion that the composite camp theory permitted a standardization of design, for in fact the training

activities of the Navy are unified only through the coordination of their management and operation. The only approach to standardization came near the end of the period of hostilities, when the detention or isolation-camp barracks were developed—this being one feature common to all camps regardless of their special activities. Toward the end, the main barracks in the general training camps were being standardized, but in nearly all of the later extensions some minor changes were necessitated to meet the requirements of a particular location.

No general scheme for the arrangement of buildings could be devised, as each site presented a different problem. Some camps, en-

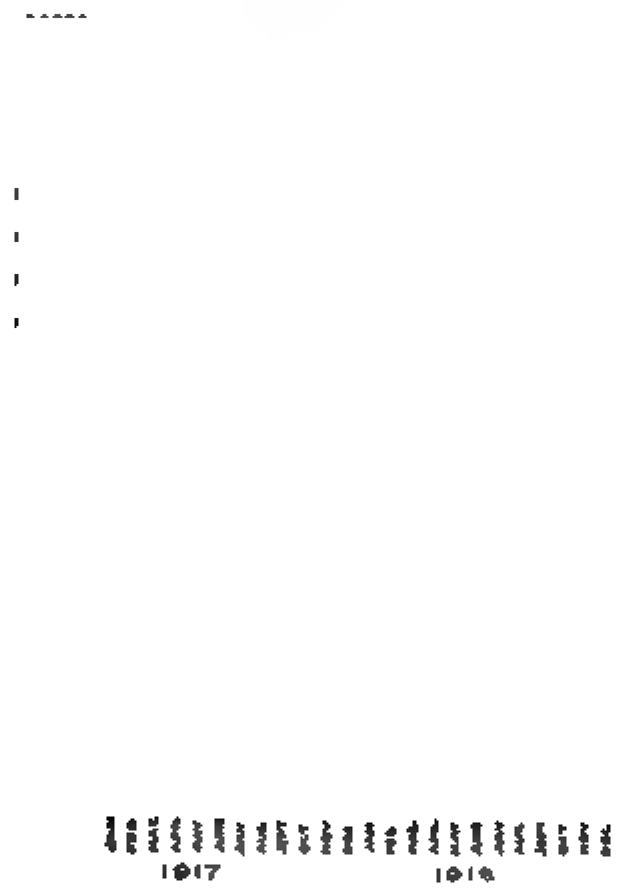


Chart showing naval recruit-training facilities as completed during emergency period.

tirely distinct from the existing naval establishment, naturally required administrative and industrial groups which were unnecessary when the new development was to become a contiguous part of an existing station. More often, the utilities to be provided presented a greater problem; in some locations the existing water supply, sewer, gas, and electric systems could be utilized, while in most instances the existing facilities, if any, were not of sufficient capacity to care for the proposed construction.

Harvard Radio School, Pelham Bay Park, City Park, and in fact most of the camps near large cities, were amply supplied by the city utilities, but on the other hand the requirements of Coddington

Point necessitated the installation of both fresh and salt water systems, the fresh water being supplied from Newport mains, while salt water for bathing, flushing, and fire protection was pumped from the bay.

The sewer problems were often difficult, and sometimes necessitated special disposal plants; and very often sump pumps were required.

East Camp, Hampton Roads, was provided with a single boiler plant for heating the entire establishment, while the topography of Coddington Point made it necessary to abandon the economy of a single plant and install three distinct power units.

The roads, walks, electrical distribution, and street and fence illumination were all items presenting individual problems at each location, and one charged with the design of similar projects must consider them as such.

The war developed two distinct types of camps, both of which were extremely satisfactory; one based on a unit system—at Great Lakes—grew to be the greatest of all, owing largely to the space available for expansion, while the other type may be described as a complete camp constructed at one time for the ultimate capacity permissible under site conditions.

East Camp, Hampton Roads, the last to be erected, was based on the latter scheme. This camp for 14,000 men, complete with the exception of an administration building, was executed in one operation, and embodies in its design all the experience gained in the construction of over 40 previous camps.

SUPPLEMENTARY.

COMPLETION OF TRAINING CAMP, CODDINGTON POINT.

One of the civil engineer officers, Lieut. Commander F. N. Bolles (C. E. C.), U. S. N. R. F., who had been on foreign duty, was ordered back to the United States shortly after the signing of the armistice, and was at once assigned duty at Newport, R. I., as officer in charge of construction for the completion of the Coddington Point project. This station was originally designed to accommodate 15,000 men, but with the signing of the armistice was curtailed to 10,000 men, and later to 8,000. The cutting down of the size of the station involved a complete redesign of all the services, such as the heating, water supply, sewer system, and electrical distribution. The total expenditures on the work were in the neighborhood of six millions of dollars.

The locations of many of the buildings had to be changed in order to make the remaining units complete, and this necessitated a rearrangement of the system of concrete roads. A great deal of design work was also necessary on the steam-heating system, the sewage disposal, and the water-front developments. A coal handling and storage plant was designed and constructed, and a boat basin and causeway, involving much dredging and subaqueous concrete placing, was also put through. This part of the work was all done during the winter of 1919–20, which was the most severe on record at Newport. There

were many days upon which it was impossible to reach the site of the work, due to the deep snows or intense cold.

The curtailment in the size of the station also meant that the several contracts covering the work had to be refigured to determine the compensation due the contractors for the work which they actually performed and for the surplus materials on the site. This proved a very arduous task, requiring several months of close application and frequent trips to Washington to confer with the authorities at the bureau.

Probably the most serious difficulty encountered was the constant trouble with the labor unions, the disputes all arising from controversies within the unions themselves as to jurisdiction over the work. Newport and Providence locals of the various trades each claimed cognizance, and as a consequence the work was tied up several times for extended periods.

EXPANSION OF NAVAL TRAINING STATION, GREAT LAKES, ILL.

(a) INCEPTION AND PUBLIC WORKS ADMINISTRATION, 1917.[1]

The Great Lakes station is situated on the western shore of Lake Michigan, 34 miles north of Chicago. It was originally constructed during the period 1905–1911, and this construction was of a substantial and fireproof character, for a designed capacity of about 1,500 men. Its cost, including hospital, harbor, power plant, tunnels, sewage disposal and water filtration systems, bridges, etc., was about $3,500,000. A large drill hall was provided, and also a large instruction building, containing classrooms, auditorium, gymnasium, swimming pool, and recreation facilites. Liberal provisions were made for showers and plumbing, all buildings were heated from a central plant, and indirect heating and ventilation were added wherever there was danger of congestion. It was a source of disappointment to the builders of the station that it was not used to its full capacity prior to 1917, owing to a more or less prevalent belief that its location was ill considered.

When, before the war started, Capt. William A. Moffett became commandant, he appreciated to the full the advantages of location and the possibilities of the station, and urged that the station be used to the limit of its capacity. When war was declared, the advantages of location were immediately proved, and he was faced with the necessity of using tents to house the large number of incoming recruits. He advocated immediate construction of camp buildings, and by interviews with the Secretary and the chiefs of the Bureaus of Navigation and Yards and Docks, he later secured approval for the construction of a camp for 15,000 men.

The Bureau of Yards and Docks was impressed with the possibilities of this station, and, cooperating with the Bureau of Navigation and the commandant, took especial interest in this construction. Inasmuch as plans had to be prepared as work progressed, and only about three months remained before cold weather, it was decided to construct the camp under cost-plus-percentage contracts for the entire job.

Instead, however, of following the Army practice of letting one contract for the entire camp, the bureau divided the main building construction into three equal parts, as nearly as could be arranged, with the object, first, of securing more rapid construction; and second, of obtaining competition in economical and efficient construction between the different contractors. This plan proved

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[1] By Commander George A. McKay (C. E. C.), U. S. N.

most successful, and as the work progressed the operation rapidly developed into a race between three principal contractors.

The original station covered a tract of land comprising 160 acres, extending about three-fourths of a mile from the tracks of the C. & N. W. and C. & M. E. Railways, east to the lake, with a water frontage of about one-half mile. The commandant, foreseeing the need of expansion, had arranged leases for large tracts of additional land, north, south, and west of the original site.

It was decided to place seven regiments of 1,700 men each, about 12,000 in all, west of the tracks, with Camp Dewey for three regiments to the north, and Camp Perry for four regiments, to the south. Two new receiving camps for observation of incoming men, of 1,700 capacity each, were planned to be located south of the original station and east of the railroad tracks. These were called Camps Farragut and Decatur. One outgoing assembly camp of 1,700 men, called Camp Ross, was located between a ravine bounding Camps Farragut and Decatur on the east and the hospital. It was also planned to construct buildings for a 1,000-bed hospital expansion, together with buildings for contagious wards. North of the original station was located the large tent camp, known as Camp Paul Jones, which it was desired to convert into wooden barracks construction by means of such enlisted labor as would become available.

About the middle of July, 1917, cost-plus-percentage contracts were let as follows:

Paschen Bros., Camp Perry, four regiments.

John D. Griffith & Son Co., Camp Dewey, three regiments plus one extra drill hall and miscellaneous buildings.

J. C. Heyworth, Camp Farragut, one regiment; Camp Decatur, one regiment; Camp Ross, one regiment; and hospital buildings of 1,000-bed capacity.

C. E. Carson Co., seven contagious wards in addition to three then under construction by same company.

Leyden & Ortseifen, roads and walks and sewage disposal system.

Leyden & Ortseifen, water supply and sewer distributing systems.

C. & N. W. Ry., bridges and railroad tracks.

The plans for hospital buildings were prepared at the bureau. Other plans were prepared at the station. Plans for sewage disposal were prepared by a firm of consulting sanitary engineers of Chicago.

The building contractors, accompanied by a committee of lumber dealers from Chicago, came to Washington in July, and with a representative of the bureau visited the various material committees organized under the Council of National Defense, and also the headquarters of the Construction Corps of the Army. Arrangements were made to secure the benefit of the standard prices for building material as agreed upon for the Army camps. In the case of lumber, however, the bureau decided upon a different course. Quotations having been received from the council's lumber committee on a sample bill of lumber taken from a preliminary plan for a barracks building, based on the proposition of shipping lumber direct from the mills, freight was added; and against this sum the lumber dealers from Chicago submitted a figure from stock in Chicago. The latter was between $7 and $8 per 1,000 board feet above the lumber committees' quotation plus freight, this difference representing the cost of unloading into yards, storage, handling, and loading for shipment out of yards. Also a better quality and higher grade of material were covered. The bureau was agreeable to accepting a bid equivalent to $5 per 1,000 above the basic figure, and this was eventually agreed upon, the lumber

dealers of Chicago binding themselves to deliver all lumber at the station as required, on 48 hours' notice, at $36 per 1,000 board feet. There was at this time a large stock of lumber in Chicago. The bureau, being much concerned in securing a completed camp by fall, considered this policy much safer than risking deliveries from the mills, already pressed by large Army orders, not to mention congested transportation conditions. As it turned out, the regularity with which the lumber was secured enabled the thousands of carpenters employed to work through the entire job without interruption or disorganization, thus effecting a saving estimated to have been practically equal to excess cost of the local supply. The bureau's prompt decision on this point permitted the camp to be completed on time. Experience on deliveries of other materials used, none so important or required so quickly after contracts were let, proved that had the lumber orders been placed at the mills as late as the middle of July, the camp could never have been completed and occupied during September and October of the same year. The bulk of the camp was occupied about two months after construction started.

Commander George A. McKay, who had been the engineer for the building of the original station, was detached from the bureau on July 16, 1917, and reported at Great Lakes as public works officer in charge of construction on July 18. Plans were under way and construction had just started under the direction of Commander Norman M. Smith. The first problem, both for Government and contractors, was one of organization. From the wealth of available personnel existing near the station the commandant had selected and commissioned a number of civil and mechanical engineers, architects, and accountants. Recruits were being received, trained, and dispatched to the fleet by thousands. There had been placed in operation a system of cataloguing these men, and among them were found a large number of trained young men with special qualifications. It was thus a simple matter to secure assistants, and the Government construction organization was rapidly perfected.

The preparation of plans was at first under Lieut. Clark, who was succeeded by Ensign Cramer when the former took charge of the material-order section. The draftsmen were either commissioned or enlisted personnel and turned out without delay the hundreds of plans required on all parts of the camp construction. All power plant, mechanical, and electrical plans were prepared by one squad and sewer and water service plans by another.

The material-order section was of particular importance. Each contractor was required, before placing orders for any material, to submit to this section a material-order request in quadruplicate, giving a description of material, the quantity, the firm or firms from whom purchase was desired, and the price. The quantity was not closely checked, as the contractor was held responsible. The material-order section would approve the price, if correct; and if not, would indicate where and from whom purchase should be made. The officer in charge of this section, Lieut. E. H. Clark, was an architect of experience in Chicago and was very familiar with the local markets. In cases of doubt he was able to secure, by telephone or telegraph, immediate competitive bids on the material in question. The fact that there were several independent contractors securing quotations on similar material helped this section to secure competitive prices. Much of the material, such as roofing, paint, piping, etc., was purchased from approved firms at prices fixed by the material committees of the Council of National Defense. Large items, such as radiators, valves, hydrants, boilers, wire rope, etc., were taken up immediately with the largest national dealers, bids were secured on the entire estimated quantities, and orders placed accordingly for all contracts. On approval of a purchase order one copy, signed by the

officer in charge, went to the contractor as authority to purchase, one to the material inspector for checking material as unloaded from the car, one to the accountant for checking of bills and preparation of vouchers for payment, and the remaining copy was retained in the material-purchase section for reference and record.

The material inspection and checking section was under the control of Carpenter C. J. Lishman, whose energy and initiative made this branch a success. He had from 30 to 40 enlisted men as checkers. These men were placed according to their past experience and every article received was tallied, inspected, and recorded as unloaded. Every stick of lumber received was surveyed and accepted or rejected, and the amounts found were sent to the accounting section for checking bills for voucher payment. As many as 67 cars of material were unloaded in a day. The section for expediting and tracing shipments, in charge of Lieut. Bower, transferred from the inspection force, performed most excellent work in securing prompt deliveries. This officer gave particular attention to boiler deliveries, and spent much time at various works expediting shop constructions. Early consideration was given to the feasibility of ordering, checking, and accounting for plumbing, steam-fitting, and electrical supplies, and of prosecuting these items of construction, and it was decided to be impracticable to attempt to check all the miscellaneous items of small parts and fittings and tools entering into these classes of work. Accordingly, as rapidly as plans were completed for each camp, bids were taken, both by the general contractor concerned and the officer in charge, and subcontracts were let through the general contractor for power plant equipment, stacks, and guys; plumbing, heating, lighting, skylight and sheet metal construction, etc. In some cases, such as for certain kitchen equipment, material was purchased direct by the Government and installed by subcontract. Cement was purchased under Navy standard contracts. The principal assistant to the officer in charge, Lieut. Willard Doud, was directly responsible for the securing and letting of subcontracts.

The chief inspector of construction over all camps, Lieut. R. K. Merrill, was ably supported by his assistants assigned to particular duties at each camp. These inspectors were directly responsible for the quality of workmanship on construction, and they concentrated on this feature. They also reported on all cases of threatened shortage of material, and were responsible for the care and inventory of tools and the prevention of waste of material.

Ensign H. A. Stanley was in charge of the accounting section and timekeepers, and had 30 to 40 assistants, mostly enlisted personnel. Under a head timekeeper 3 or 4 timekeepers, as required, were assigned to each contract. Each workman, on reporting, secured his time check, which he carried with him during the day and deposited on leaving at the completion of a day's work—these operations being witnessed by the timekeepers. In addition to this, the timekeepers passed from building to building and group to group, and checked the men by name and check number once each morning and each afternoon. If a man was not found on the work, in addition to checking in and out morning and evening, he was not paid. Thousands of men were employed and many, particularly laborers, were foreigners, mostly Italians. The checking was most thoroughly done, and resulted in several arrests being made for attempted impersonation. Payments were witnessed by the same timekeepers.

To prevent the unauthorized presence of strangers in the camps, each workman wore an enameled badge bearing the name of the contractor and a number corresponding to that on his time check. These badges also assisted in identifying the men, particularly on the special transportation trains from Chicago.

Another case of petty fraud uncovered was in the abuse of transportation tickets. Three special trains carried about 1,500 workmen each to and from Chicago daily. These men traveled on 25-ride interchangeable commutation tickets purchased by and carried by the contractors' timekeepers, who passed through the train with the conductor, identified the workmen, and counted and paid for the number traveling on each contract. It was suspected that enlisted men and others were at times passed and paid for by some of the contractors' timekeepers. Arrangements were made to put three chosen enlisted men on each train on a certain day, with the result that fraud was discovered and those guilty were discharged. A liberal estimate was made of the extent of the loss, and it was charged back to the contractors. Following this, all checking of men on transportation trains was performed by the Government timekeepers.

The accounting section was also responsible for all payments. Toward the end of each month each contractor assembled all paid bills and pay rolls and forwarded these, in duplicate, to the accounting office. These were checked and each original was attached to an original of public bill for the monthly payment by the Government. As the vouchers came to the public-works officer for signature, each individual receipt was initialed by, first, the man responsible for the correctness of the price paid, as compared with the authority to purchase; second, by the man responsible for quantity, as compared with the material inspector's report; third, by the man responsible for the correctness of arithmetical extensions; fourth, by a man responsible for general features, such as debits for discount for prompt payment when conditions of purchase so permitted, which debit was taken by the Government, whether advantage of the discount had been taken by contractor or not; examination as to whether voucher was an original paper or duplicate and properly executed, etc. Finally it was initialed by the head of the accounting section for complete certification. Certain monthly vouchers on certain contracts amounted to nearly three-quarters of a million dollars and covered hundreds of transactions, yet they were put through for payment in a few days. It was necessary, however, to throw out at times doubtful bills, pending further analysis, and these were taken up on the following month's vouchers.

The foregoing covers that part of the public works organization dealing with contract work. The quickness with which the organization was assembled and commenced operation, and the results obtained, were possible only because the young men available were of the highest standard. The section heads particularly showed marked efficiency in initiation, judgment, energy, and tireless effort. Every man in the organization appeared to realize the importance of his particular duty as a link in the complete chain, and every man was hard pressed to keep his section from dragging. There was no question of hours, and work proceeded through Sundays and holidays, many putting in 12 hours a day.

Inspectors' reports of trouble were discussed, and suggestions made for speeding construction, at organization conferences held thrice weekly, at 5 p. m. Advantage was had of individual experiences, and each was inspired to harder effort by the accomplishments of the others. Speed and cost were given the closest attention, and the question, "What will be found wrong when the camp is used?" was constantly before the conference for study, with the result that when winter came the anticipated troubles did not materialize. The Government organization as a whole rapidly became most proficient, and, as in the case of other camp performances, records were constantly being broken. When in the fall it was discovered on a Saturday morning that an additional boiler plant of 900 horsepower was necessary as a result of the addition of a number

of buildings along the north side of the original station, it was decided to construct an additional heating plant. The boilers required were located, by long-distance telephone, at Kewanee, Ill. The Chicago agent was found (on the golf links), the boiler dimensions were secured, and the boilers ordered. Plans were then drawn, bids taken, contracts let, materials secured, and in 15 days after the plant was first thought of, the building, boilers, stack, piping, and underground connections were completed and the plant was delivering steam.

The contractors employed, when work was at the maximum, in August and September, approximately 6,000 men. The majority of the buildings were occupied in September, and all in October, except for certain buildings ordered later, and except for the hospital buildings. The latter were delayed until November, their commencement having been deferred pending the completion of certain railway facilities. The first wards were ready on November 6, the others following rapidly, and the last two wards were completed by November 28.

There were constructed in the summer and fall of 1917 approximately 450 buildings, containing 33,000,000 cubic feet, and requiring 50 acres of ready roofing. There were 26 separate boiler plants, containing 81 boilers giving a total of 7,112 boiler horsepower. In all, 324,160 square feet of radiators were used, with 103 miles of heating mains. Plumbing fixtures totaled: Closets, 1,875; lavatories, 2,051; showers, 1,518; sinks, 605; other fixtures, 481. Total lumber used by contractors was 23,806,135 board feet. About 3,500 carloads of material were used on the contract work. The maximum number of cars discharged in one day was 67.

The costs on the contracts covered in the foregoing amounted to $5,507,571.22.

This construction, together with Camp Paul Jones (constructed by enlisted forces) and the original station buildings, gave accommodations, without crowding, for about 27,000 men.

(b) PUBLIC WORKS ORGANIZATION AND STATION DEVELOPMENT, 1918.[1]

The expansion effected at Great Lakes in 1917 provided most satisfactorily for the emergency that had arisen, but the beginning of 1918 saw no intermission in the tide of recruiting from the Middle West, which, by the fall of the year, was to demand a station capacity of at least 50,000.

The public works officer, Commander W. H. Allen, who arrived on the project in January, 1918, to relieve Commander McKay, found the 1917 camps completed and occupied, and he proceeded at once to the duties lying ahead.

Modifications of the former organization were effected, in line with later and relatively stabilized construction conditions. The organization finally adopted in the spring of 1918 is outlined below.

Directly under the public works officer was the executive officer, Lieut. Commander Doud, whose duties, as the title implies, were to see that the orders of the public works officer were carried out and that the work of the various sections was properly performed. He handled all the minor details of the office.

The force was organized into several divisions, as follows: The clerical division under a chief clerk, Mr. H. C. Litchfield, which looked after all work of correspondence, accounting, and making requisitions; the projects division under Lieut. Munroe, which had charge of all drafting, specifications, and surveying; the contract division under Lieut. Clark, which took charge of the supervision of all work done through Yards and Docks contracts; the station labor division under Lieut. Beard, which had charge of all the work done by the enlisted and civilian force, both construction and maintenance and operation, and which

[1] By Commander W. H. Allen (C. E. C.), U. S. N.

was divided into several sections, such as the building section, power section, transportation section, grounds section, and railroad and coal section; the regimental division, under Lieut. Davis, which had charge of the military work of the department and handled all matters of personnel.

The work done under Bureau of Yards and Docks contracts was all done under a lump sum, with the exception of that let early in the war. In 1917 there were 14 contracts awarded at a total cost of $5,561,000. In 1918, 60 were awarded, amounting to $11,370,000. Contracts awarded in 1919, but under which a large part of the work had been done during the war, were four, totaling $104,000. The total of all contracts performed during the war was thus, approximately, $17,000,000.

Contract work progressed rapidly, and at the time of the armistice there were only two or three contracts which could be modified by the omission of work. Final liquidation was delayed in numerous cases through refusal of contractors to accept settlement, but within three months after the armistice there was only one contract awarded during the war which had not been entirely completed so far as all construction work was concerned.

In 1918 the work was as rapid as in 1917. The most important contracts were as follows: Contract No. 2835 with Paschen Bros., for $1,374,000, for the construction of the aviation mechanics' school; contract No. 2859 with Paschen Bros.. for $2,134,000, for the outgoing detention camp; contract No. 3247 with English Bros., amounting to $2,259,000, for three regimental units (Camp Lawrence); contract No. 3303 with Paschen Bros., for $849,000, for the Naval Auxiliary Reserve school; contract No. 3304–A with C. E. Carson Co., amounting to $875,000, for additions to Camp Paul Jones; contract No. 3459 with Paschen Bros., amounting to $364,000, for three drill halls and power houses.

The contract division at its height comprised 176 enlisted men experienced on structures, plans, and construction work and accounting.

Practically all plans for construction at the station were prepared in the projects division of the public works department. The chief exceptions were a few buildings at the hospital and the outgoing detention camp. This division made some notable records, among which might be cited the preparation of the plans and specifications for Camp Lawrence, a project which cost over $2,000,000. As soon as the Secretary had authorized the work the public works officer, who was in Washington at the time, telegraphed orders to begin the preparation of plans; and 11 days after the work was authorized the public works officer started for Washington again with the plans and specifications, which comprised over 100 drawings and more than 200 typewritten pages of specifications. In preparing these plans men worked in relays, and the specification writers in the last few nights worked continuously except for two or three hours of sleep.

The work of the station labor division consisted chiefly of the maintaining of the station. There was assigned to each regiment a detachment from the public works department, who looked after all maintenance work of that regiment, including the operation of the power plant, the repairs to buildings, all services, and the minor alterations constantly going on. It was found necessary, on account of the great area covered by the station, to build public works barracks in Camps Perry and Decatur; one battalion of the public works regiment, consisting of 800 men, occupied the former barracks, and 450 men were located in the latter. The main part of the public works regiment lived in Camp Paul Jones, but there were other barracks and parts of barracks throughout the whole station occupied by public works men. This system of carrying on the regimental maintenance by trained men from public works was found far superior to the method of having the regiments look after their own maintenance, since they

did not possess the trained force, the qualified supervision, nor the incentive. The method followed tended toward uniformity of the work in each regiment.

As a natural consequence of the large force in the public works department, a great deal of construction was done by enlisted men. Several jobs of considerable magnitude were undertaken and carried through successfully, but the greater part of their work comprised a very large number of small jobs, in the nature of additions and alterations to the regimental buildings and the general buildings on the main station.

The transportation section, which included the operation of motor vehicles, was one of the busiest branches of the department. Vehicles were not detailed, but were all operated from the central organization. A large shop was built and was constantly kept busy with the repair and rebuilding of these motor vehicles. One very interesting incidental performance of the transportation section was the driving to places in the East of trucks bought by the Navy Department in the vicinity of Chicago. Some 30 to 40 trucks were taken east in this manner, the first making the trip to New York, a distance of more than 800 miles, in five days. The saving to the Government in time of delivery when railroad transportation was so badly congested amounted to many weeks.

Another very interesting work was the expedition sent to the St. Claire River Flats Canal to repair the barracks for the patrol force at that place. This expedition took its own equipment, camped on the site, and built barracks most expeditiously. Much work was done also at the municipal pier in the city of Chicago for the school and camp of three or four thousand men maintained at that place. The organization of the regiment for rescue work at the time of the Mississippi valley floods, in the spring of 1918, was thorough, and the expedition was ready to start on an hour's notice. Fortunately, conditions did not develop so grave as to require its services.

Certain types of construction are believed to be peculiar to the Great Lakes station, if not to have originated there. Chief among these is the H-shaped type of barracks, the washing and toilet rooms of which are located in the cross of the H. This made possible the locating of four companies of men on each floor of the building, each having its own toilet and latrine facilities. The final development of this type was a two-story building providing eight barracks rooms, each with a capacity of 36 men on the Bureau of Medicine and Surgery standard, but capable in the summer season of holding 60 men without crowding or menace to health.

The drill halls, with McKeown arches, reached a high state of development at this station. The standard type had a span of 100 feet and a length of 500 or 600 feet, but one hall built to accommodate two regiments with a capacity of 6,000 men, was 800 feet long with a span of 120 feet. Some of these buildings were partitioned off for instruction purposes and for shops.

The type of detention building differed somewhat from that used at other stations. It comprised simply two rooms for the one-story type and four rooms for the two-story type, with a capacity of 12 men per room. The food was brought to the men in thermos cans from the central galley of each regiment.

The mess halls of the training camps were divided into company rooms for the purpose of better control of men during meal hours, and also with some thought of isolation in case of epidemic. There were 12 to 16 mess rooms in each building, all served from a central galley by a long corridor extending lengthwise of the building. The first mess halls were not of the self-service type, but later this feature was introduced and steam tables were installed in each mess room.

The finest camp built on the station was Camp Lawrence, the last completed. Here the number of buildings was reduced to a minimum, there being three regimental units, each containing six barracks buildings, housing 300 men each, and two H-shaped buildings of the same size as the barracks, which contained the regimental offices, the instruction rooms, the storerooms, the dispensary, the isolation wards, and barracks for the maintenance force and band. One mess hall served each regiment, one power house and one drill hall served two regiments, and one laundry and one garage served the whole camp. The power houses and mess halls backed against the railroad spur, so that the operating cost of the camp was reduced to a minimum.

The athletic building, together with the grand stand, the baseball and football fields, and the running tracks, comprised an athletic unit hardly to be equaled in the country. The grand stand had a capacity of 15,000. One of the few 440-yard straightaway tracks in the country was built. The athletic building itself, aside from the offices of that department, provided lockers for the various teams, dormitories for visiting athletes, handball courts, and a swimming pool.

Mention should be made of the water filtration and sewage disposal features at this station. They were increased several fold during the war, embodied the latest features of sanitary engineering, and were at all times adequate for the station population, which at its maximum was 48,300 men.

CHAPTER V.

MARINE CORPS PROJECTS.

The work undertaken by the Bureau of Yards and Docks for the Marine Corps included several large and important undertakings and a large number of minor projects, such as quarters for marine guards at various points. One of the most noteworthy constructions was the extension to the quartermaster storehouse in the city of Philadelphia, for which contracts were awarded in September, 1917. A new barracks building to accommodate 400 men was designed and constructed in the Philadelphia navy yard, the contract being awarded November 26, 1917. An advance-base storehouse in the same yard was contracted for in June, 1917, and completed in December.

New barracks were designed for the American legation guard in Peking, China, and for the naval station at Key West, and a quartermaster storehouse and post exchange was built at the naval station, Pearl Harbor.

The largest project for the Marine Corps which the bureau has undertaken is the construction of an expeditionary base on a site selected by the Commission on Navy Yards and Naval Stations, at San Diego, Calif. It is intended that this base shall be a model of its kind, and it is estimated that the entire project, when completed, will cost approximately $5,000,000. The site which was selected was low land, some of it submerged at high tide, and a considerable amount of filling was required before the construction of buildings could be commenced. In addition to barracks to accommodate about 1,700 marines, there will be an administration building, gymnasium, quartermaster storehouse, expeditionary storehouse, power plant, with laundry and bakery attached, dispensary, guardhouse, officers' quarters, water supply and sewerage systems, electric lighting, heating, and refrigerating systems, a sea wall, a shipping pier, and all the other accessories necessary to make the base complete in every respect.

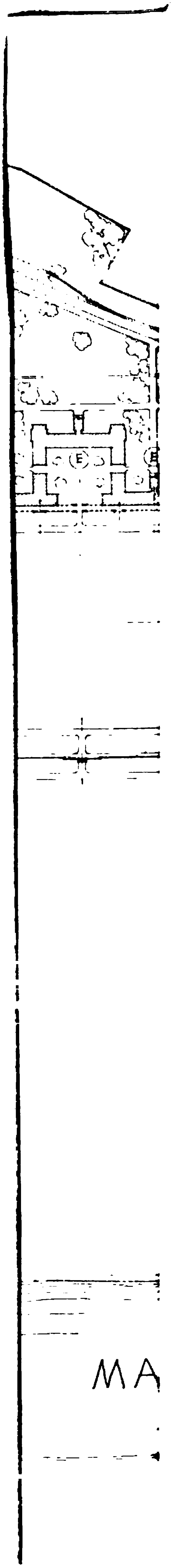
In compliance with directions of the Secretary of the Navy, the Bureau of Yards and Docks on March 26, 1918, submitted tentative plans for a barracks to accommodate 500 marine guards for the navy yard, Portsmouth, N. H. The resulting contract, awarded on July 8, 1918, and completed November 23, 1918, provided a two-story building of a permanent type including under one roof complete facilities for housing and messing 545 members of the marine guard, and in addition, barracks for 40 cooks and messmen.

At the declaration of war, along with the rest of the Navy, the personnel of the Marine Corps increased rapidly, and it became necessary to provide rendezvous for its recruits where the necessary training and instruction might be conducted on a large scale. After the Marine Corps had arranged the preliminaries, the Bureau of Yards and Docks on June 4, 1917, awarded a contract, which originally contemplated the construction at Quantico of 272 buildings; but various additions increased this total to 320 temporary buildings, together with the utilities necessary to house, mess, and train 6,900 men. The contract included shops, artillery sheds, dispensaries, offices, officers' quarters, and a hospital for 100 beds, with accommodations for a hospital personnel numbering 51 persons. This contract was completed in the early part of March, 1918, and still further expansion of the station was realized by construction work, which began on June 24, and was completed November 30, 1918, furnishing additional facilities for 2,200 men in the infantry, 400 in the artillery, and 200 in officer schools, besides providing a hospital extension for 200 beds.

The original source of water at Quantico was artesian wells, but the flow proved insufficient, and a supply was developed by the construction of a dam in Chappawamsic Creek, with a pumping station and filtration plant some 4 miles from camp.

Parris Island was selected as a site for a Marine training camp, and the immediate need for housing there was realized at the outset of the war. To this end the Bureau of Yards and Docks on April 21, 1917, awarded a contract to cover the construction of approximately 233 temporary buildings, together with all appurtenances. The work, completed by March, 1918, provided facilities for 3,000 men and auxiliary buildings for an additional tent camp of 2,000. A later extension of this camp under a bureau contract was started on July 24, 1918, and when completed (December, 1918), this afforded additional quarters for 4,100 men, together with the necessary auxiliary buildings, alterations of existing structures, extension of the hospital, and construction of piers, officers' quarters, etc., in all about 288 buildings.

The water supply of Parris Island was taken from wells, a test of which showed a considerable quantity of salt. The only source of fresh water being transportation by barge from the mainland, the salt water was distributed for bathing, washing, flushing, and fire protection, while fresh water was distributed by a small-pipe system to the hospital and main station, and by tank wagons to the camps, for drinking and cooking purposes. Even with strict supervision the increase in population soon overtaxed the existing system, and it was not until a submerged pipe line to Port Royal was completed that the island was provided with an adequate supply of fresh water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Bird's-eye perspective of Marine Corps Base, San Diego, Calif., as proposed

Parade ground, Marine Corps Base, San Diego, Calif.

CHAPTER VI.

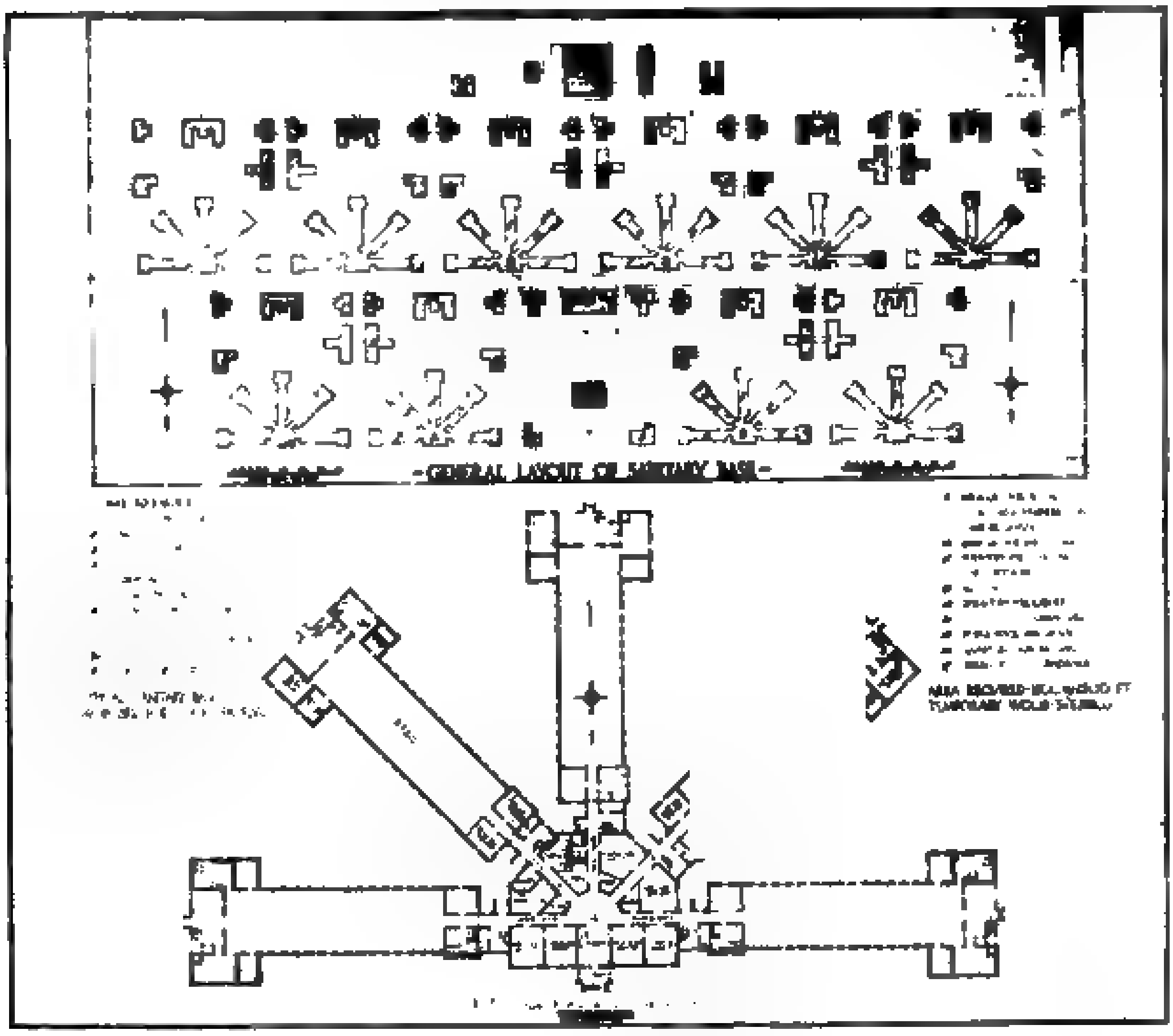
EMERGENCY HOSPITAL CONSTRUCTION.

General.—In 1916, subsequent to the beginning of the World War but previous to the entrance of the United States in the conflict, the Bureau of Yards and Docks, after consultation with the Bureau of Medicine and Surgery, prepared drawings for two hospital bases to accommodate 5,000 patients each. The plans were drawn, assuming that one hospital base would be established on the east coast and the other on the west coast. The buildings were carefully designed and checked with information obtained by a representative of the Bureau of Medicine and Surgery while he was on a trip of inspection in Germany during the early part of the war.

When the United States entered the war, the idea of the two large naval hospital bases was abandoned. Plans for increasing the capacities of the then established hospital centers were substituted for the plans of the two large hospital bases. A sudden call for naval hospital accommodations necessitated the development of a type of hospital for quick construction and easy expansion. It was found that material for and the construction of buildings of the same approximate dimensions as those being used by the Army could be more readily obtained for hospital purposes than those shown by other designs. Consequently, the first hospital construction was based on the Army barracks unit. When, however, the Bureau of Medicine and Surgery had been provided with facilities to keep abreast of the demands of the service, plans were prepared for hospital layouts to be subsequently erected which were larger, more efficient, and more satisfactory for the needs of the hospital service. The width of the Army unit was too small for advantageous use for general hospital work.

Where new hospitals were to be erected at a distance from an existing hospital station, a complete self-sustaining group was designed, providing its own heating plant, laundry, disinfecting apparatus, storehouse, and buildings needed to meet the usual requirements for administration, subsistence, and operating purposes. These unit groups were designed for capacities of 100, 150, and 200 men per group, consideration being given to possible expansion, such as occurred in several units.

The first units were of wood construction, one story high, with drop-siding exterior, ready-to-lay roofing, and with interiors sheathed with wood ceiling or prepared ceiling board as the case might be. Covered walk ways were provided for communication between ward,



Prewar design for hospital bases, east and west coasts.

administration, subsistence, and operating buildings. At the close of the war there were in operation in the United States and Hawaii 27 hospital centers, as shown below. The normal bed capacities provided by the emergency construction are also indicated.

Hospital center	Bed capacity, emergency construction.	Hospital center.	Bed capacity, emergency construction.
Portsmouth, N. H.	225	Hampton Roads, Va.	750
Chelsea, Mass.	1,000	Charleston, S. C.	715
Newport, R. I.	312	Parris Island, S. C.	185
New London, Conn.	150	Pensacola, Fla.	200
Brooklyn, N. Y.	750	Key West, Fla.	150
Wards Island, N. Y.	800	Gulfport, Miss.	150
Pelham Bay, N. Y.	750	New Orleans, La.	200
Grays Ferry Road, Philadelphia, Pa.	300	Great Lakes, Ill.	1,500
League Island, Philadelphia, Pa.	775	Fort Lyon, Colo.	....
Cape May, N. J.	200	Mare Island, Calif.	550
Washington, D. C.	300	San Diego, Calif.	500
Quantico, Va.	300	Puget Sound, Wash.	100
Annapolis, Md.	100	Pearl Harbor, Hawaii.	....
Norfolk, Va.	1,275		

Seaplane view of Naval Hospital, Chelsea, Mass., showing emergency units.

Seaplane view of Naval Hospital, Wards Island, N Y.

As mentioned hereinafter, there had been established 13 overseas hospitals.

The figures noted above are actual normal bed capacities, and do not take into account the use of porches or solaria for bed patients; nor do the figures include the Medical Corps and associated personnel, for whom suitable provision was also made.

At the naval hospital, Pearl Harbor, Hawaii, and at the naval hospital, Fort Lyon, Colo., only limited emergency hospital construction was undertaken, as there was ample provision for all probable war needs. At San Diego, Calif., temporary buildings previously used for the San Diego exposition and several portable buildings, accommodating in all about 500 patients, were used, with the intention of keeping these structures in commission until the completion of the permanent naval hospital in Balboa Park, San Diego, about February, 1922.

The first groups of emergency hospital buildings to be erected were started at Philadelphia (League Island), Pa., Charleston, S. C., Pensacola, Fla., and New Orleans, La. The buildings for these bases were all one story in height and formed complete units. The first groups at Pensacola, New Orleans, and Charleston provided 200 beds each, and the one at League Island 275 beds. These hospitals were quickly followed by other units.

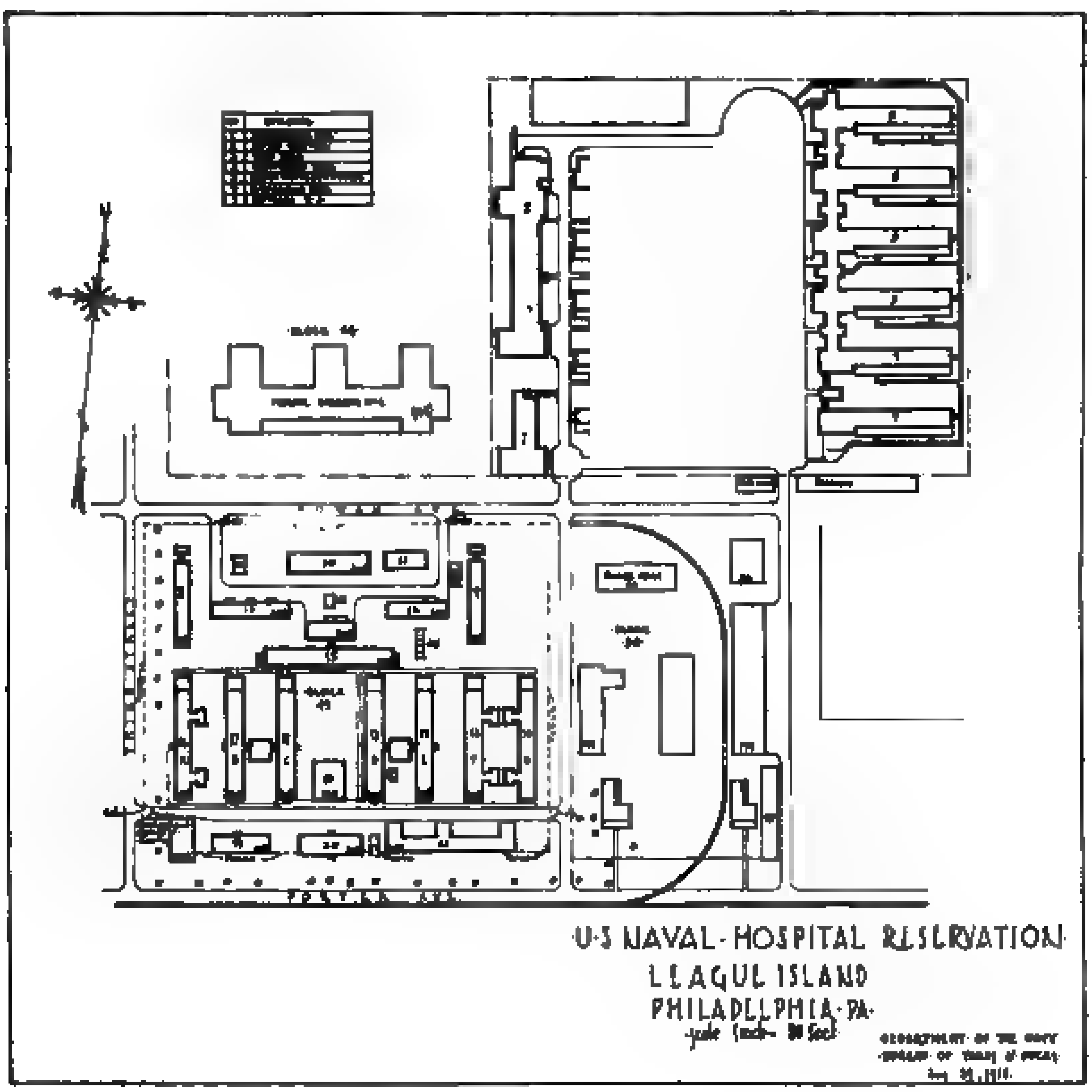
The emergency hospital construction at Portsmouth, Chelsea, Newport, Brooklyn, Grays Ferry Road (Philadelphia), Washington, Annapolis, Norfolk, Parris Island, Great Lakes, Mare Island, and Puget Sound was grouped around existing permanent hospital construction. The hospital groups at New London, Key West, and Gulfport were built up around existing construction not of Government ownership. That at New London comprised a memorial hospital of wood frame construction, a brig, a contagious-disease hospital, and a just completed but unoccupied almshouse.

At Key West, buildings belonging to a church school were utilized to provide hospital facilities. The property was finally purchased by the department, and has become a permanent hospital reservation.

At Gulfport, the recruit training station made use in great part of the exposition buildings in process of construction at the time of the war. The hospital buildings constructed to provide space for the sick of the camp were one story in height, wood frame, similar to the buildings at New Orleans and Charleston, but the layout was increased by the use of portable buildings.

The emergency work at Wards Island, Pelham Bay, League Island (Philadelphia), Cape May, Quantico, Hampton Roads, Charleston, Pensacola, and New Orleans was completed as a unit at each of the stations.

Wards and subsistence building, Naval Hospital, League Island, Philadelphia, Pa.



Plot plan of Naval Hospital, League Island, Philadelphia, Pa.

Ward buildings, Naval Hospital, Charleston, S. C., showing connecting covered walk.

Plot plan, Naval Hospital, Charleston, S. C.

About 500 major hospital buildings exclusive of dispensaries were constructed in the United States, providing for a patient and attendant personnel of 17,000. The work included not only the buildings, but also heating, lighting, and plumbing facilities, and roads and walks.

On account of the fact that plans and specifications for several hospitals had to be prepared simultaneously, and on account of the limited number of draftsmen available at the bureau, it became necessary to obtain the services of several architects to prepare drawings and specifications under the direction of the bureau. Appreciation is expressed for the efforts of Messrs. Ewing & Allen for their work at Pelham Bay, N. Y., Grays Ferry Road, and the navy yard, Philadelphia, Pa.; for the work of Mr. C. Grant La Farge at Brooklyn, N. Y.; and for the work of Mr. J. H. de Sibour at Annapolis, Md.

Appropriations.—Appropriations totaling $21,045,000 were made by Congress for the hospital construction, and $550,000 for medical supply depots. The appropriations are itemized below:

Appropriations.

FOR HOSPITAL CONSTRUCTION.

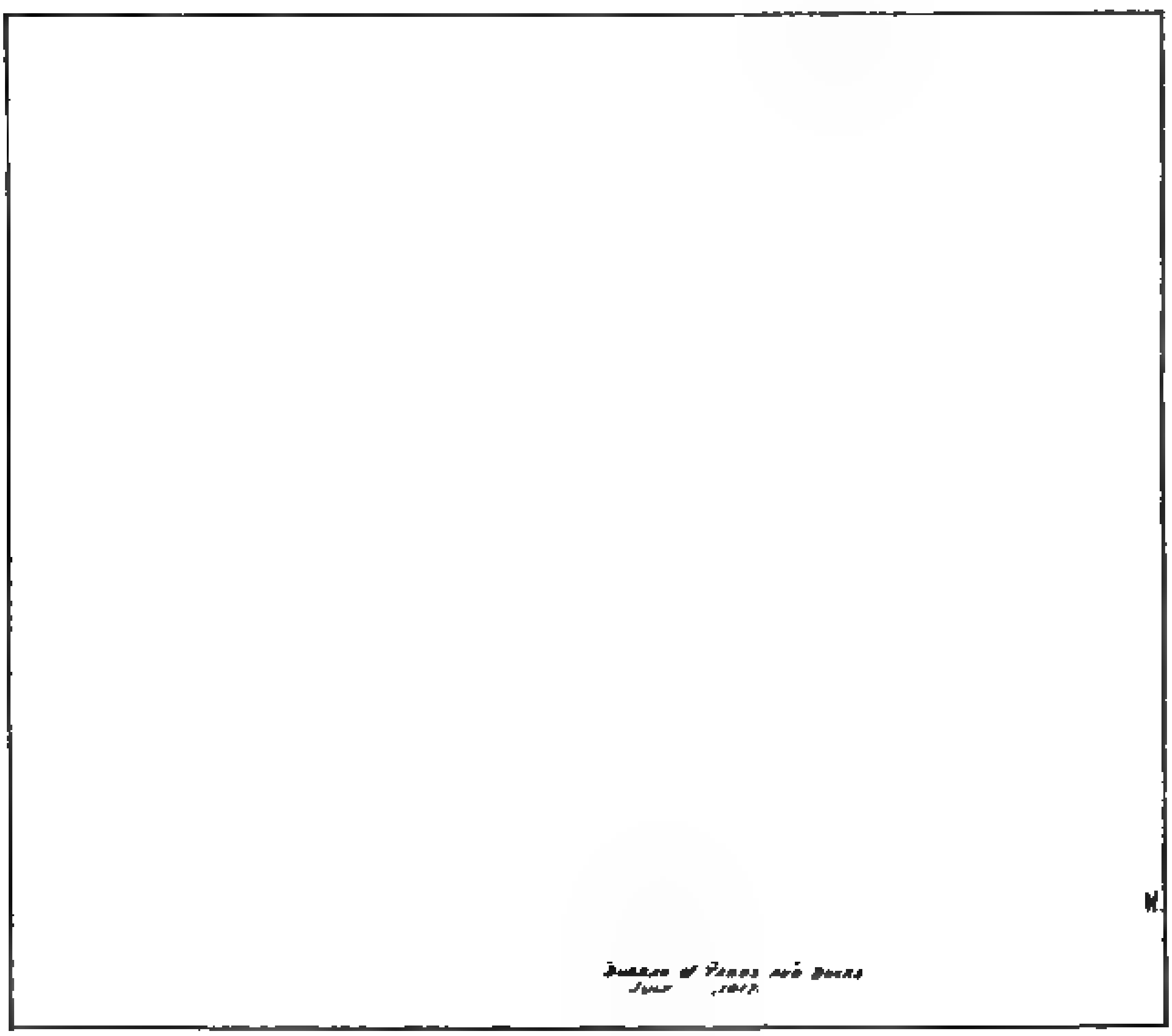
Act.	Purpose specified.	Amount appropriated.
Deficiency act, June 15, 1917	Temporary hospital construction	$1,000,000
Deficiency act, Oct. 6, 1917	Temporary hospital construction and repairs, etc	2,000,000
Deficiency act, Mar. 28, 1918	....do	2,750,000
Naval act, July 1, 1918	Hospital construction	10,295,000
Deficiency act, Nov. 4, 1918	Temporary hospital construction	5,000,000
Total appropriated for hospital construction		21,045,000
Turned back to Treasury Jan. 29, 1919		1,008,742
Total for hospital construction		20,036,258

FOR MEDICAL SUPPLY DEPOTS.

Deficiency act, June 15, 1917	Naval medical supply depots, Brooklyn, N. Y., and Mare Island, Calif.	$350,000
Deficiency act, Nov. 4, 1918	....do	200,000
Total for medical supply depots		550,000

Costs.—The cost per bed at the different emergency hospitals varies greatly, owing to local conditions and requirements—notably as to amounts of road work, grading, and service lines necessary. The emergency hospital at Charleston, S. C., typical of the greater part of the program, cost approximately $650 per patient, including laundry and kitchen equipment. This figure, of course, includes the cost of all buildings necessary for housing the doctors, nurses, hospital corpsmen, and other attendants. The cost on a straight per capita basis for the entire personnel would fall somewhat below $500.

Psychiatric wards, Naval Hospital, Portsmouth, N. H.

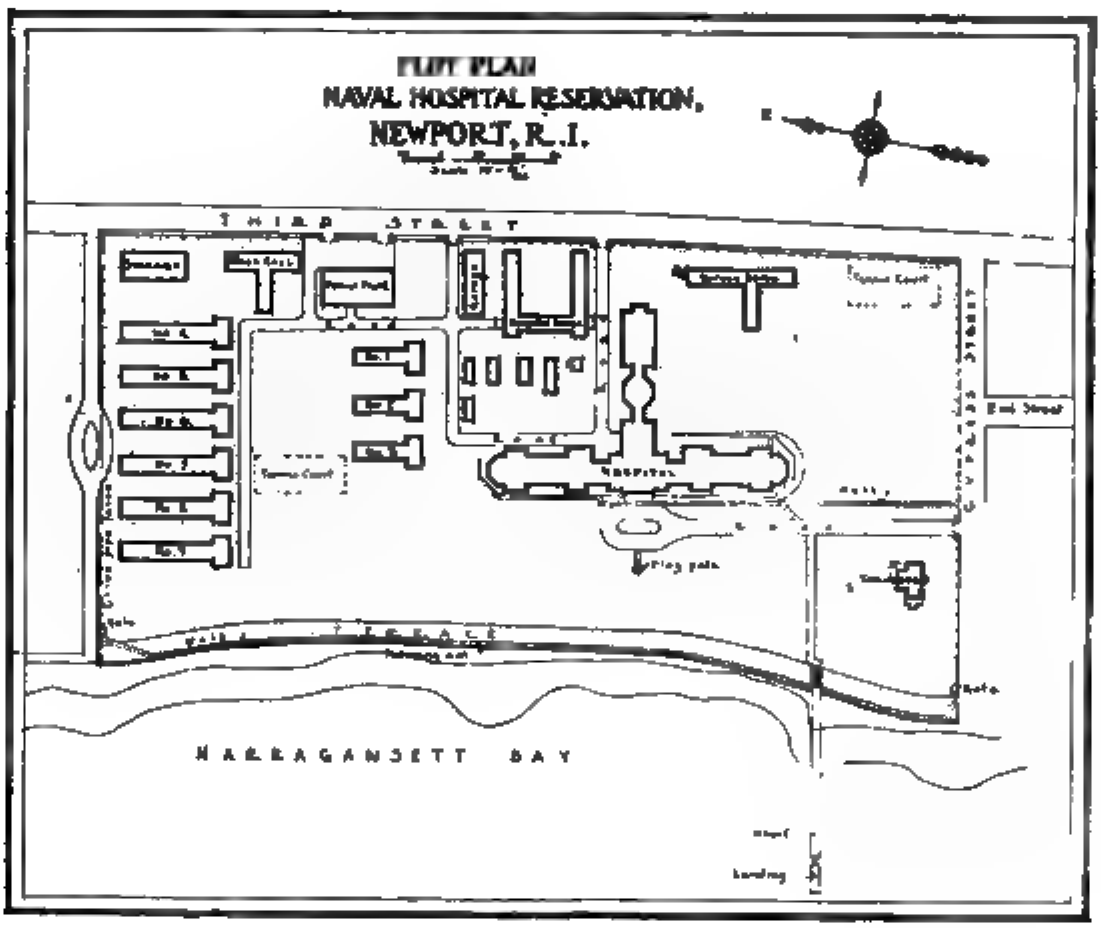


Plot plan of Naval Hospital, Portsmouth, N. H.

Ward building, Naval Hospital, Chelsea, Mass.

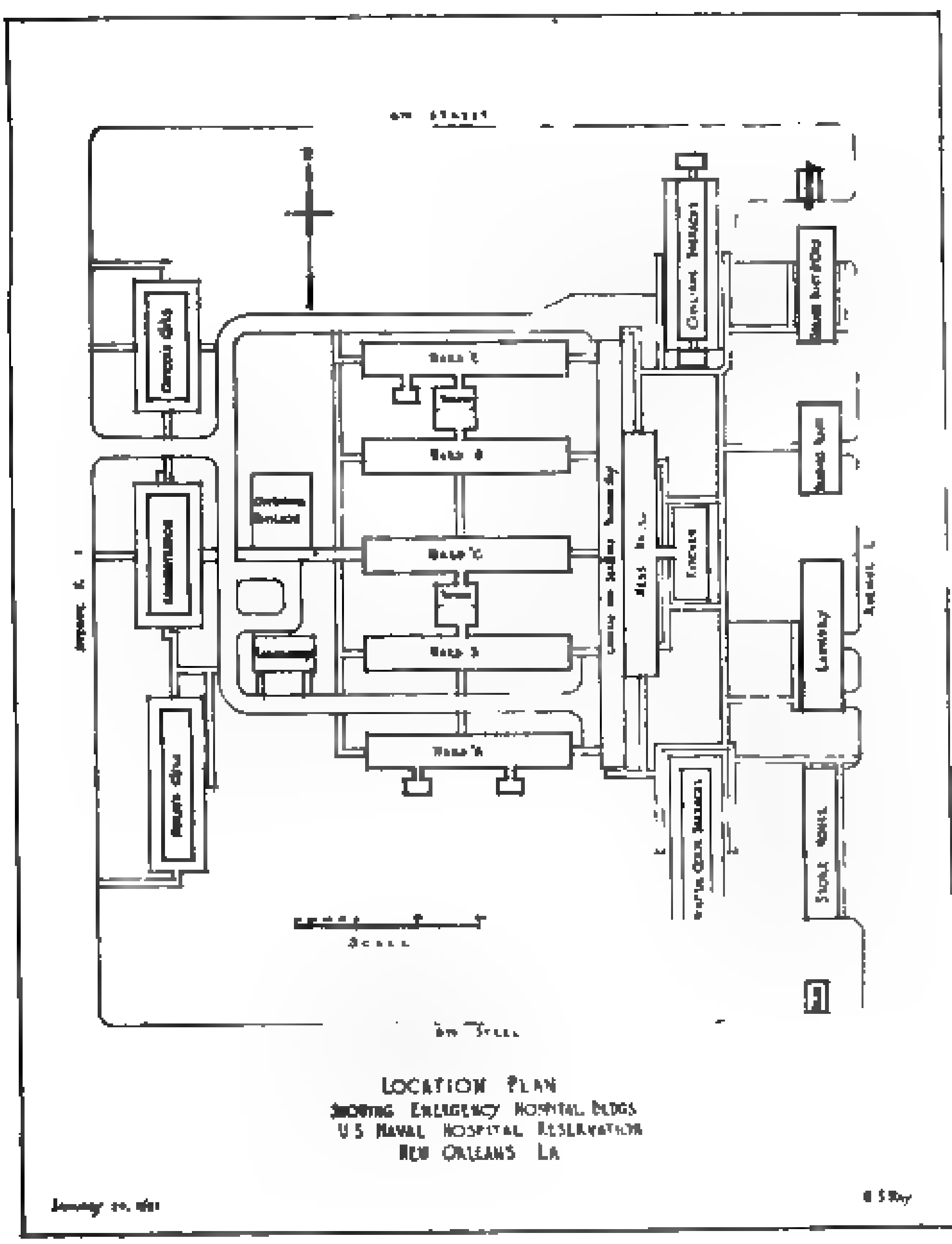
Solarium end of ward buildings, Naval Hospital, Chelsea, Mass.

Contagious wards, Naval Hospital, Newport, R. I.



Plot plan, Naval Hospital, Newport, R. I.

Administration building, Naval Hospital, New Orleans, La.



Plot plan, Naval Hospital, New Orleans, La.

Ward buildings, Naval Hospital, New Orleans, La.

Emergency buildings, Naval Hospital, Norfolk, Va.

The work at Wards Island was probably the most expensive of the war construction, owing to the difficulty in obtaining labor at the site, and added cost for transportation of materials. The expense of the concrete roads and service lines was exceptionally high. Based on a capacity of 800 beds, the cost of the Wards Island emergency hospital was about $2,000 per bed; or per capita, including all personnel, about $1,600. Items entering into the cost of this project not necessary at other plants were an expensive power house stack, and power house modifications at the Manhattan State Hospital for the Insane, necessary to equip that plant for serving the hospital. As noted elsewhere, the original capacity at this point was to have been 1,200 beds, or a total personnel of about 1,800. Had the additional wards been constructed, the cost per bed would have been materially reduced on account of the fact that administrative, service, operating, and other general buildings would have provided ample facilities without increase in size.

New Orleans, La.—The naval hospital at New Orleans was one of the first of the emergency groups to be constructed, and is typical of the earliest hospital work. The layout remained intact through the war and was not modified by additions. The grouping of the buildings was such that the service of the hospital would bring a patient to the administration building for examination or to the operating pavilion for operation or for dressings. A covered walk way was laid from the administration building to the operating pavilion and thence to the surgical ward, so that surgical patients would not have to be carried through the open. One ward was separated from the others by a drive, making it possible for observation cases to be carried to the isolated ward without passing through any other building or corridor space. This same ward building had separate toilets, so that the main wardroom might be partitioned for use in contagious cases. Each ward building provided facilities for 40 patients, nominally.

The general mess was divided to secure separate messing space for patients, hospital corps, doctors, nurses, stewards and pharmacists, and civilian employees. Only one kitchen or galley was found necessary, so that the labor of preparing and serving the food was reduced to a minimum. Inclined walks from the kitchen provided means for easy transportation of food carts to the various wards.

The laundry was placed in the rear of the group near the heating plant, and as far as possible from the wards. All service for the reservation, except for entrance of patients and doctors, was confined to the rear of the hospital.

There were 19 buildings in the group, as follows: Administration, sick officers' quarters, nurses' quarters, operating pavilion, labora-

tory, laundry, five wards, mess hall, galley, hospital corps barracks, shop building, heating plant, laundry, storehouse, and mortuary.

Norfolk, Va.—Of the Atlantic coast emergency hospital development Norfolk was the largest, with New York a close second, though at New York there were a great many patients who were cared for in civilian hospitals. Immediately upon the declaration of war by the United States, provision was made at Norfolk for hospital accommodations in excess of those afforded by the permanent buildings. The first construction was of an exceedingly temporary character, consisting of platforms on which were built wood frames to take wood wainscoting about 4 feet high, above which were canvas curtains. The roofs were covered with a temporary impregnated paper The buildings were heated, and served their purpose until a more durable construction could be provided.

The next step in this development was the construction of eight one-story ward buildings and two subsistence buildings placed directly back of the main hospital building. The wards were placed radially to follow the semicircular drive in the rear of the hospital. Each ward provided about 50 beds, with the necessary quiet rooms. toilet rooms, and diet kitchens. This group was used continually until the armistice, but was vacated as soon as practicable thereafter on account of the proximity of the buildings to the main hospital group and the resulting fire hazard. In connection with the eight wards and two subsistence buildings there were provided four hospital corps barracks, each one story in height, of the same construction as the wards, namely, exterior drop siding, ready-to-lay roofing, composition board interior cover for studs, and wood frame.

In accordance with a request from the Bureau of Medicine and Surgery, plans were developed for the construction of a hospital to provide 1,500 beds in addition to the two groups of hospital buildings just mentioned. The total capacity for the Norfolk hospital under normal conditions would then be 3,000 beds.

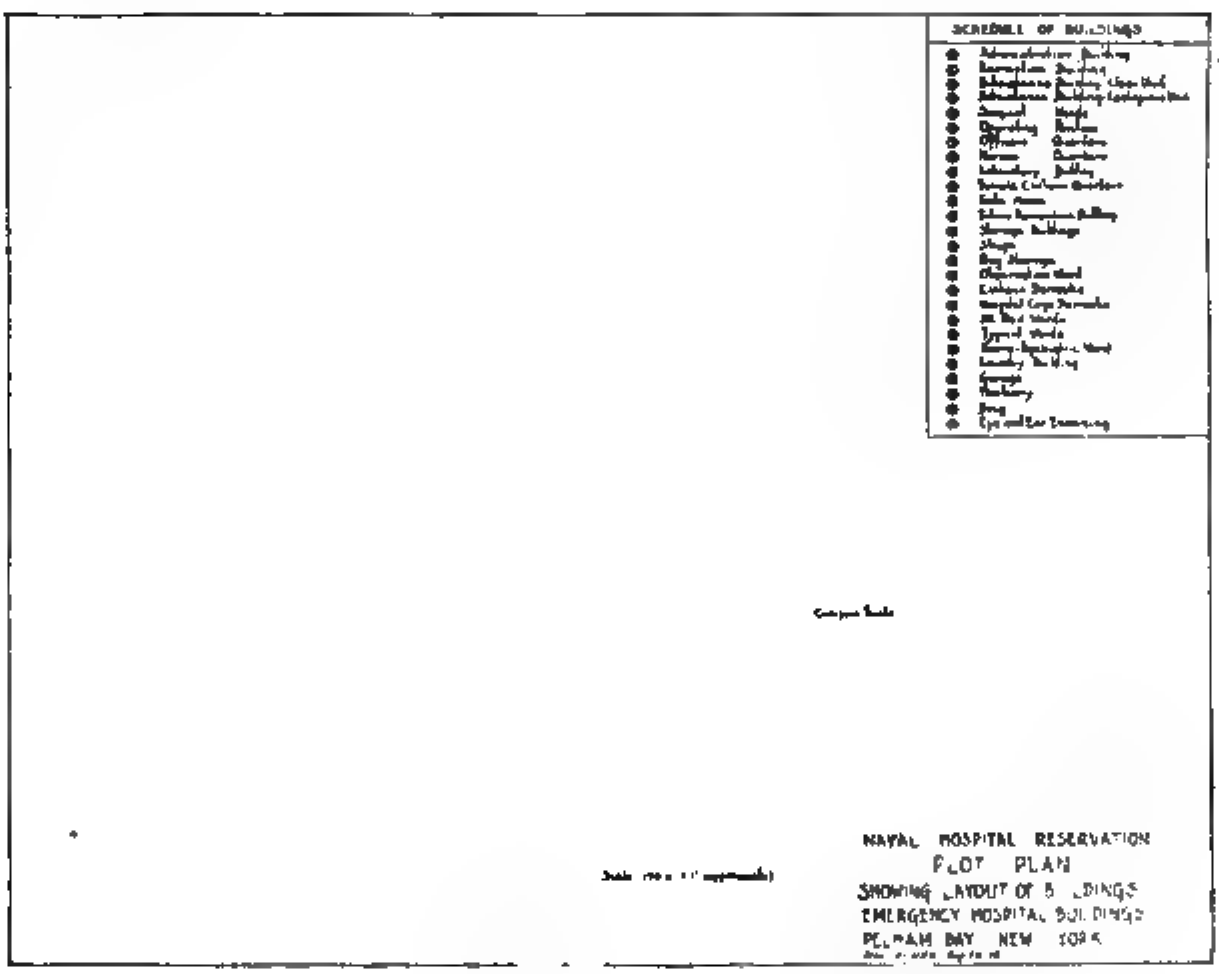
The 1,500-bed hospital was divided into two proposed groups—one for the ordinary or "clean" cases, and the other for contagious diseases, to provide 900 beds. Only the latter group was placed under contract, on account of lack of funds to complete the entire layout. There was included in this contract one of the ward buildings required for the future "clean" case group, which was partitioned for nurses' quarters. Before the construction of this last group was started, it was necessary to remove the emergency group first erected.

The 900-bed project, partially occupied at the time of the armistice. was of terra-cotta wall construction, with wood framing for floors

Main hospital and emergency group, Norfolk, Va

Plot plan of Naval Hospital, Norfolk, Va.

Surgical ward, Naval Hospital, Pelham Bay, N. Y.



Plot plan, Naval Hospital, Pelham Bay, N. Y.

and roofs. The roofs were covered with asphalt-impregnated paper having a crushed slate finish. The buildings were two stories in height, and were arranged to provide ward space for either general medical or contagious cases. Surgical cases were cared for in the main or permanent hospital buildings.

Pelham Bay, N. Y.—The site for the emergency hospital buildings at Pelham Bay was one of the most attractive of the hospital locations. Two groups were built. The first, a hospital for 250 beds, was incorporated in the main training camp, and was built concurrently. The capacity soon became too limited for the needs of the rapidly increasing personnel, and a second hospital to provide 750 beds was built near the isolation camp. The buildings of this group overlooked Pelham Bay. When they were placed in commission the first group was transferred to the use of the main camp for general requirements.

The second hospital consisted of about 48 buildings, and housed a personnel of about 1,100. The plans incorporated all the improvements that had been developed up to that time during the war. Buildings were arranged for contagious-disease observation cases and neuropsychiatric treatment in addition to the general wards for surgical and medical cases. Lighting, heating, and power were provided from the training station plant. The hospital had complete laundry facilities, and was one of the few groups to have an especial building for recreation purposes built by the Government. In many cases, as hereinafter stated, the American Red Cross donated recreation buildings, and in other cases certain portions of available buildings were set aside for these purposes.

Washington, D. C.—The most rapid of the hospital building operations was at the naval hospital, Washington, D. C., to increase the capacity of that establishment.

Instructions were received on September 27, 1918, to prepare drawings and outline specifications for emergency hospital buildings to provide facilities for about 300 patients. The contract was signed on October 4, 1918, and was delivered to the contractors on October 5. Work started the same day on the construction of six buildings. The time given for the completion of the work was 60 calendar days. The buildings were finished within the contract time, and in fact not only completed, but entirely furnished and equipped to the smallest detail, including window curtains. The structures comprised two observation ward buildings, two general ward buildings, a subsistence building, and a power house, including stack.

The observation ward buildings were designed with deep screened porches to admit of the treatment of pneumonia cases in the outside

air. The stories of the observation buildings were divided into small wards with easily accessible toilets, sterilizing rooms, etc.

The general ward buildings provided wards for about 30 patients each, with all the necessary service rooms.

The wards and subsistence building were of wood frame construction, covered with metal lath and cement-mortar stucco. The ward buildings were two stories in height and the subsistence building and power house were one story. The latter was of brick construction and, owing to soil conditions, it was necessary to form a monolithic concrete foundation for the chimney. The roofs were covered with ready-to-lay roofing finished with crushed slate.

The buildings cost approximately $415,000 and the equipment about $50,000.

Brooklyn, N. Y.—The hospital buildings at Brooklyn were the only ones of fireproof construction in the emergency program, although the Wards Island buildings and parts of the Norfolk, Grays Ferry Road (Philadelphia), and Chelsea groups were of the slow-burning or fire-retarding type. The permanent construction at Brooklyn was approved by the Secretary, both on account of the extreme fire hazard to which the buildings at the existing hospital would otherwise be subject, and also on account of the fact that the use of the buildings as ultimate parts of the permanent hospital was unquestioned.

The buildings were two and three stories in height, with reinforced concrete frame, floors, and roofs, and with stuccoed terra-cotta walls. Stucco was of a tint to match the original hospital buildings constructed of a light sandstone. For war service large wards were designed to care for 40 patients instead of 30 (the Navy standard number). Other wards, and also quiet rooms, were provided for 24 or 18 beds. All materials for the Brooklyn hospital were specified to be the best of their respective kinds.

The nurses' quarters built at Brooklyn provided facilities for 130, with a separate room for each nurse. It is fireproof in construction, and is the best and most complete of all the nurses' quarters. It consists of two stories and basement, and provides a commodious living room and a large dining hall that can be used for lecture purposes.

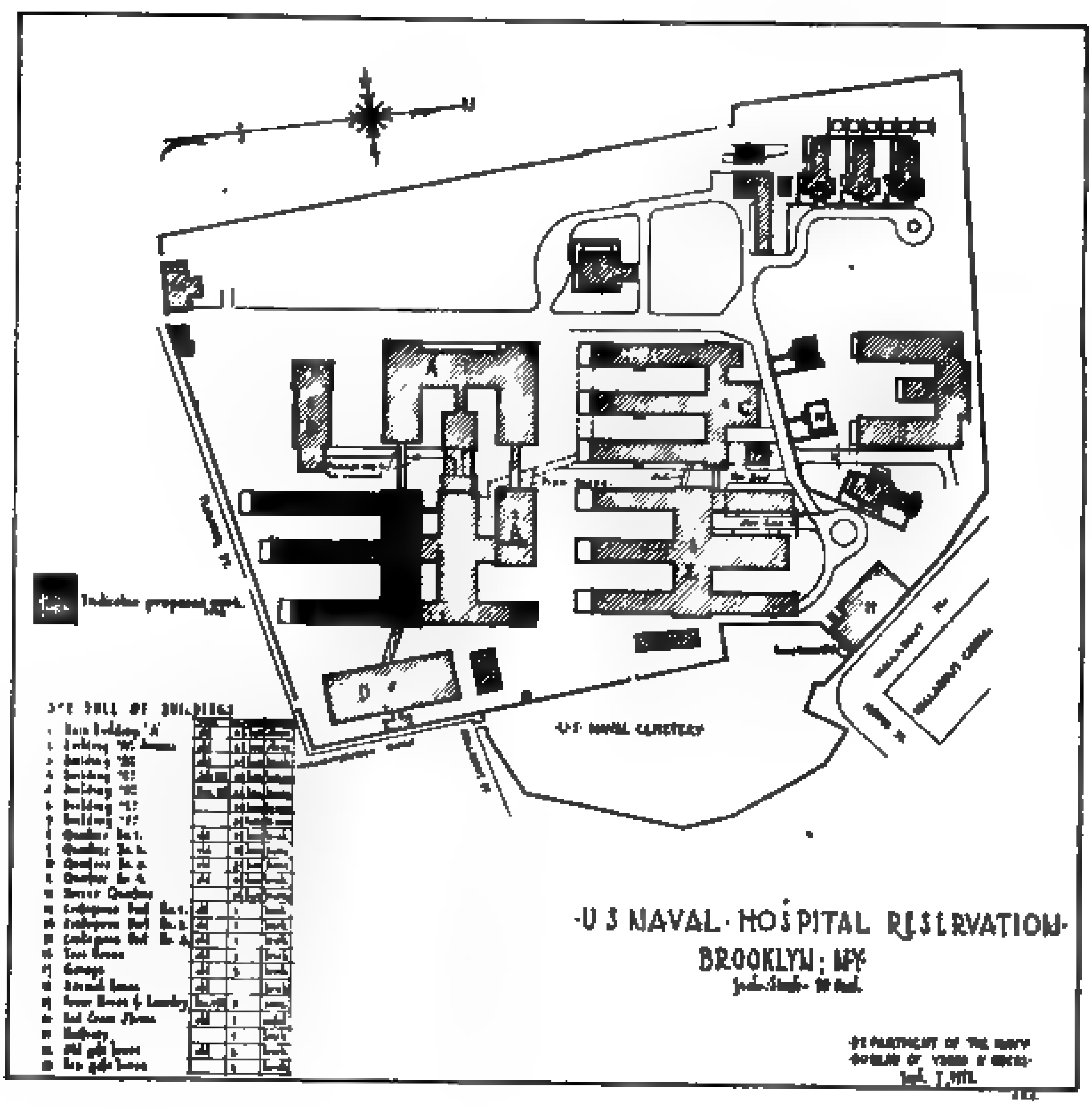
Wards Island, N. Y.—A site near New York was required for the construction of an emergency hospital supplementary to the Brooklyn facilities and in addition to the several hospitals that had been commandeered for Navy use. Many buildings and private institutions were inspected with a view to utilization by the Navy before it was decided to build, but no suitable buildings were found.

The Wards Island property was brought to the attention of the Secretary of the Navy and the Surgeon General, and finally a lease

Emergency buildings, Naval Hospital, Washington, D. C. (eastern group).

Emergency buildings, Naval Hospital, Washington, D. C. (western group).

Emergency buildings, Naval Hospital, Brooklyn, N. Y.



Plot plan of Naval Hospital, Brooklyn, N. Y.

Building "F", Naval Hospital, Brooklyn, N. Y.

Nurses' quarters at emergency hospital, Wards Island, N. Y.

Plot plan of emergency hospital, Wards Island, N. Y.

was signed whereby the State of New York was authorized "to enter into an agreement with the Navy Department covering the use of approximately 28 acres of the grounds of the Manhattan State Hospital at Wards Island, New York City, as a military measure, for a period not to exceed two years beyond the termination of the present war." It is probable that, had the war continued, the group erected under this agreement would have been used for contagious cases, although at the time of the armistice it was being used as a general hospital. The buildings, together with a considerable amount of kitchen equipment, were turned over to the State of New York after the Bureau of Medicine and Surgery ceased to utilize them.

The Wards Island emergency hospital was designed to care for about 1,200 patients and an attendant personnel of about 600. Before the contract was awarded, however, the required number of patients was cut to 800, so that the total personnel would be approximately 1,200. The figure 800 was the normal capacity, and could have been increased by 25 per cent by the use of porches, closer bed spacing, etc.

The group included 21 buildings, comprising an administration building, sick officers' quarters, nurses' quarters, Hospital Corps barracks, civilian employees' barracks, receiving building, laboratory, mess halls, galley, 14 ward buildings, operating building, garage, laundry, and storage. Heat and power were supplied by the Manhattan State Hospital power plant. (See paragraph "Costs.") The buildings were of terra-cotta tile, stuccoed on the exterior and plastered on the interior. Partitions, floors, and roof construction were of wood frame. Asphalt-impregnated paper with crushed-slate finish was used for roof covering.

It was necessary to construct a wharf for the use of the hospital so that traffic would not in any way hamper or affect the routine of the Manhattan State Hospital, which occupies the island. With its own landing facilities provided by the wharf, the reservation was completely independent of the rest of the island.

Canceled projects.—Drawings and specifications were prepared for hospitals at Halifax, Nova Scotia, Hingham, Mass., and Yorktown, Va., but for various reasons the execution of the projects was abandoned.

The Halifax hospital was proposed for 200 beds, making a total personnel of 300. The cost of the work was to be borne by the American Red Cross, and the estimate for the construction work was $150,000. The bureau was asked by the Red Cross to prepare the drawings and specifications, let the contracts, and provide inspecting and constructing forces. The site had been chosen, the plans and specifications were ready, a civil engineer and a paymaster had been assigned to duty for the work, and the contractor selected, when

the society decided to modify the construction and advertise the buildings locally at Halifax. The project was finally abandoned altogether, owing to a change in the war plans of the British and the United States Governments. The hospital had been intended for the use of returning troops.

For the naval magazine reservation at Hingham, Mass., there was projected a dispensary hospital providing 100 beds—20 for contagious diseases and 80 for the usual medical and surgical cases—besides dormitory and living space for attendant personnel. It was at first intended to care only for emergency cases at Hingham, but the distance to Chelsea, the naval hospital of the first district, is so great and the trip so perilous during the winter months that it was thought necessary to make the Hingham establishment more or less complete.

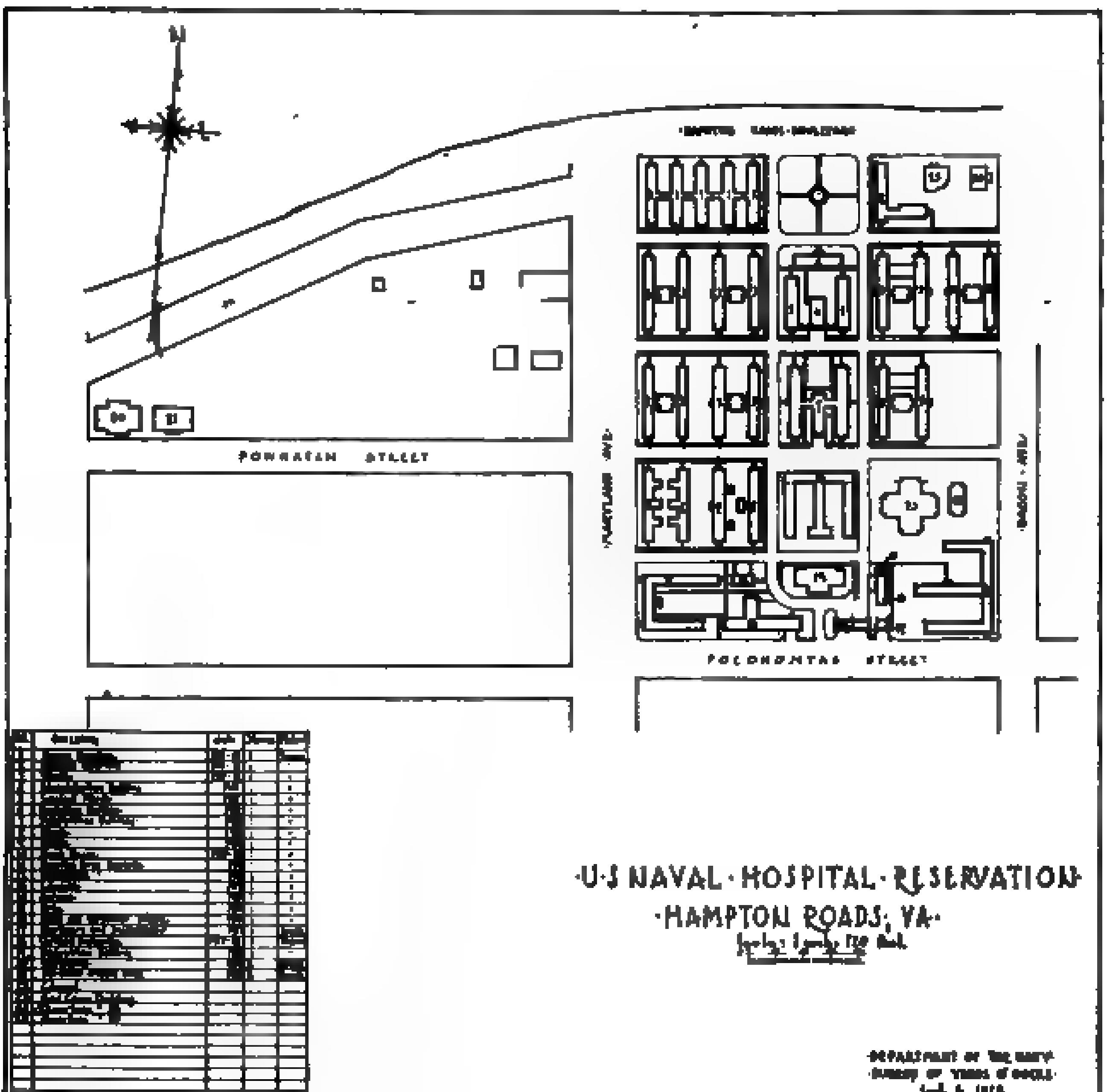
The contract for the work was awarded on October 10, 1918. for $257,885. After the construction work had been started, however, the armistice was signed and the Secretary gave instructions to suspend the work. The bureau ordered the suspension of the work on November 23, 1918, and the contract was finally settled under a supplemental agreement allowing $64,431.92 to cover the materials purchased and the work done.

On September 9, 1918, proposals were to have been opened for a training camp at Yorktown, Va., to provide accommodations for 14,000 men. A complete hospital layout provided facilities for 800 patients, and a personnel of 400 doctors, nurses, Hospital Corps men, and civilian employees were provided for in the drawings. The decision of the department, however, to establish a second camp at Hampton Roads instead of a new layout at Yorktown, as noted elsewhere in this volume, eliminated all features of this project. The hospital group at Yorktown constituted 30 buildings, as planned. The structures were to be of wood construction, colonial in type, and one story high, except that the administration building and Hospital Corps men's barracks were to have been two stories high.

Laboratories.—During the war laboratory work assumed an importance and volume that outstripped all facilities that had been provided. At some of the larger hospitals, as, for instance, those at Great Lakes, Chelsea, Pelham Bay, and Norfolk, several buildings were constructed on plans developed to meet the needs of the service.

Recreation buildings.—Recreation facilities were provided at all of the hospitals. In several cases the American Red Cross constructed buildings and transferred them to the Navy for its use. Where buildings were not erected especially for recreation purposes, space was allotted for the use of the personnel for games, reading, writing, smoking, etc.

Ward buildings, Naval Hospital, Hampton Roads, Va.

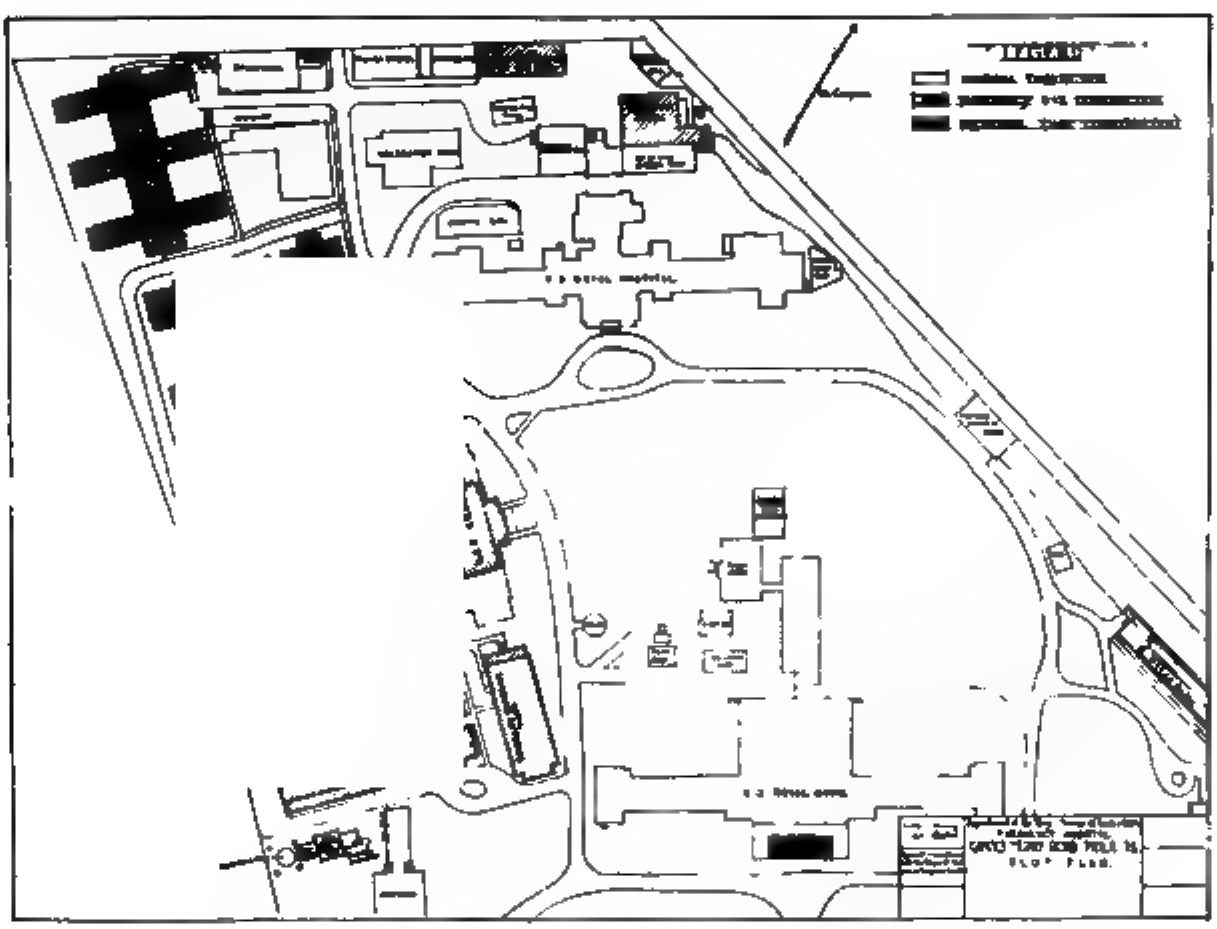


Plot plan of Naval Hospital, Hampton Roads, Va.

Ward interior, Naval Hospital, Hampton Roads, Va

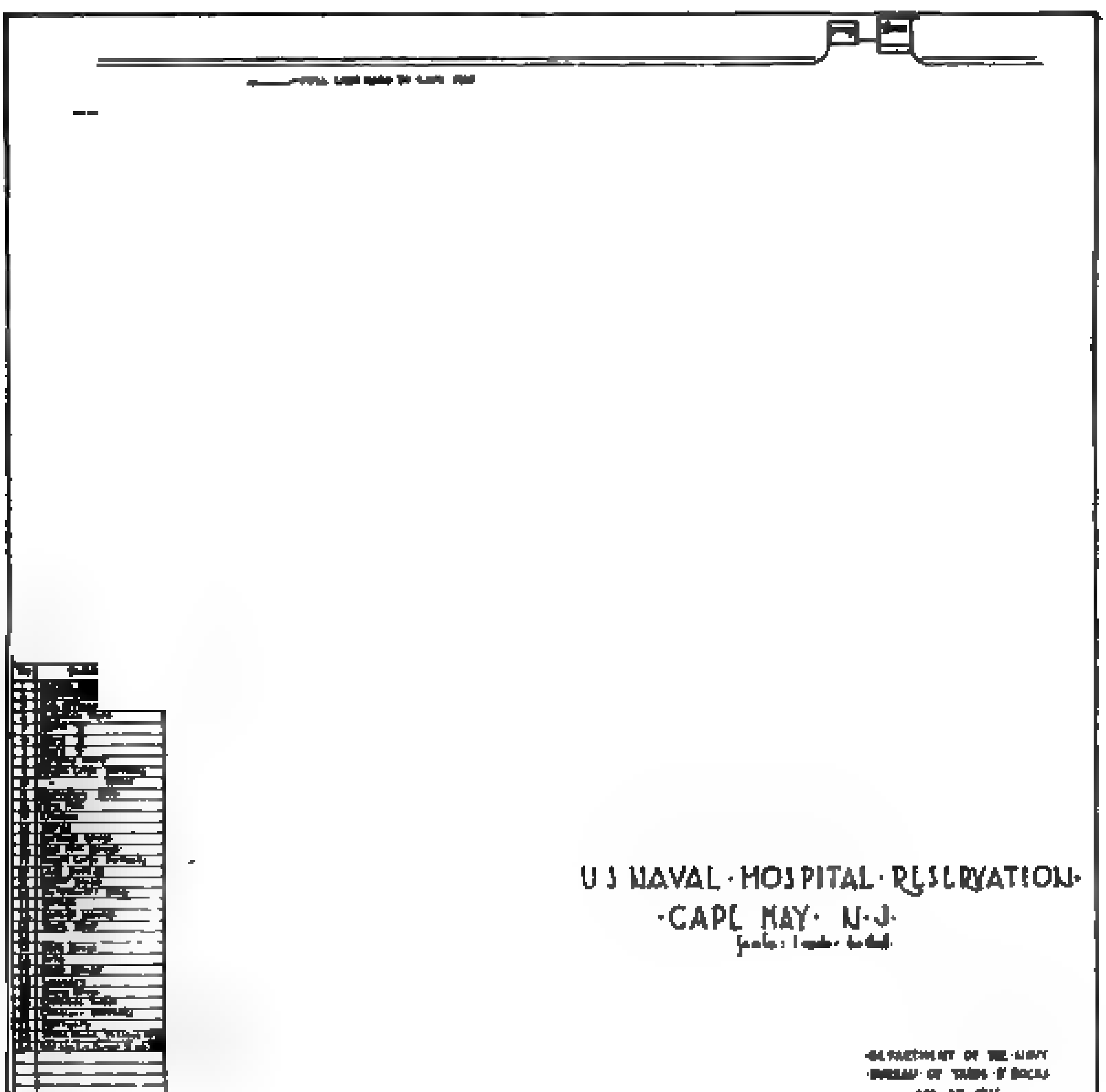
Emergency hospital buildings, Marine Barracks, Parris Island, S. C., showing wards and solarium.

Ward buildings, Naval Hospital, Grays Ferry Road, Philadelphia, Pa.



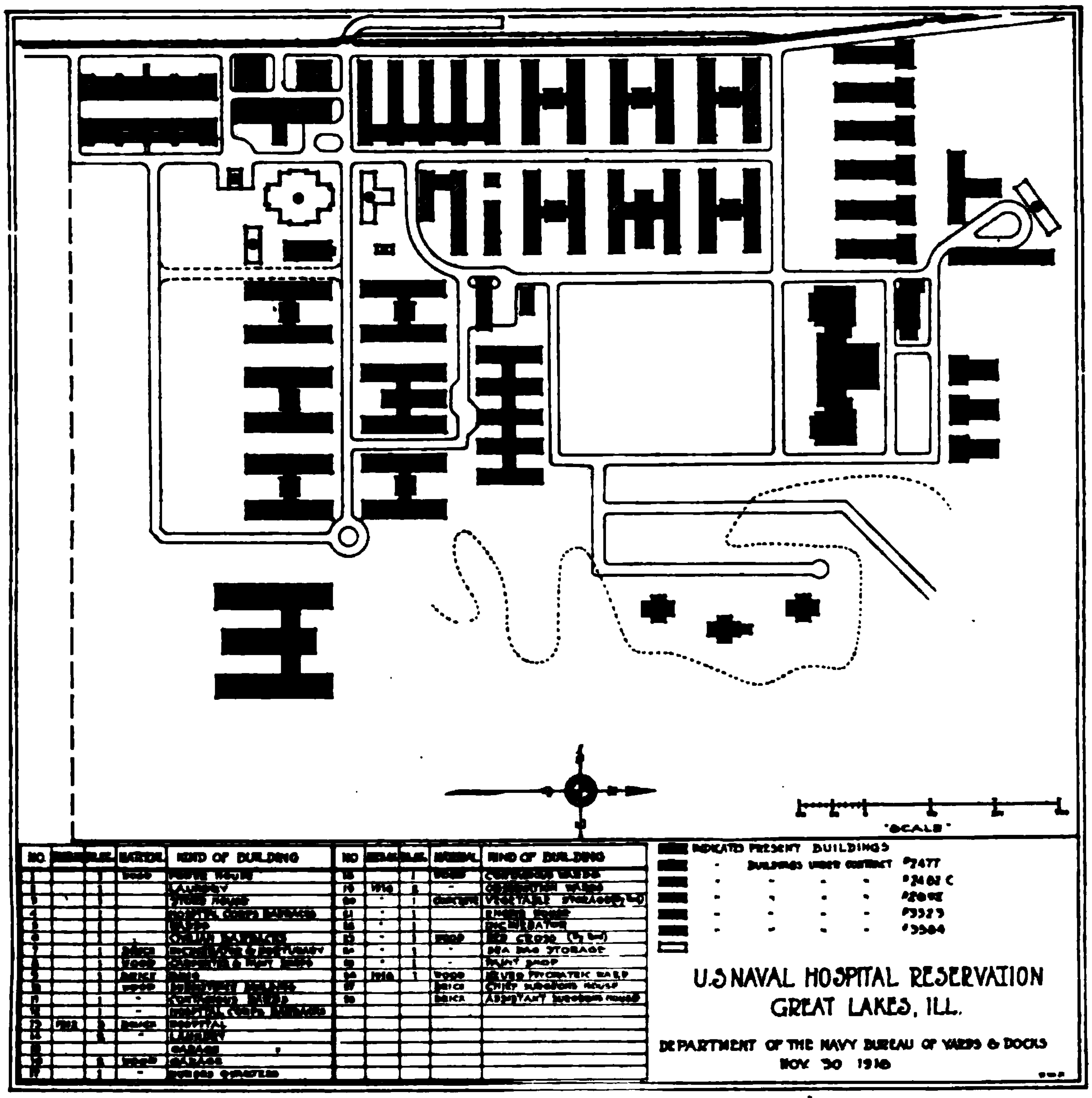
Plot plan of Naval Hospital, Grays Ferry Road, Philadelphia, Pa.

Isolation ward, emergency hospital, Cape May, N. J.



Plot plan of emergency hospital, Cape May, N. J.

Dispensary buildings.—In addition to the regular hospital service, dispensaries were established for all training camps and for all activities where there were groups of men. Approximately, the facilities provided were for 2 per cent of the personnel of the station. The dispensary buildings contained ward space, the usual rooms for dispensing medicines and filing prescriptions, accident rooms, examining rooms, diet kitchens, nurses' rooms, and cubicles. The cubicles consisted of isolation rooms with toilet facilities and an attendant's room. The isolation rooms were used for suspicious or undetermined



Plot plan of hospital reservation, Naval Training Station, Great Lakes, Ill.

cases. If the case developed into a contagious disease, it was sent immediately to the hospital. Otherwise, if the case were not serious, the patient was transferred to the dispensary ward.

Overseas construction.—Facilities for the care of Navy patients overseas were provided in two ways, first, by the use of portable buildings shipped from the United States, and second, by the use of existing buildings acquired through lease or purchase and not under any cognizance of the Bureau of Yards and Docks.

Approximately 200 portable buildings were shipped abroad. These were 20 by 32 feet, one story in height, and cost, on an average,

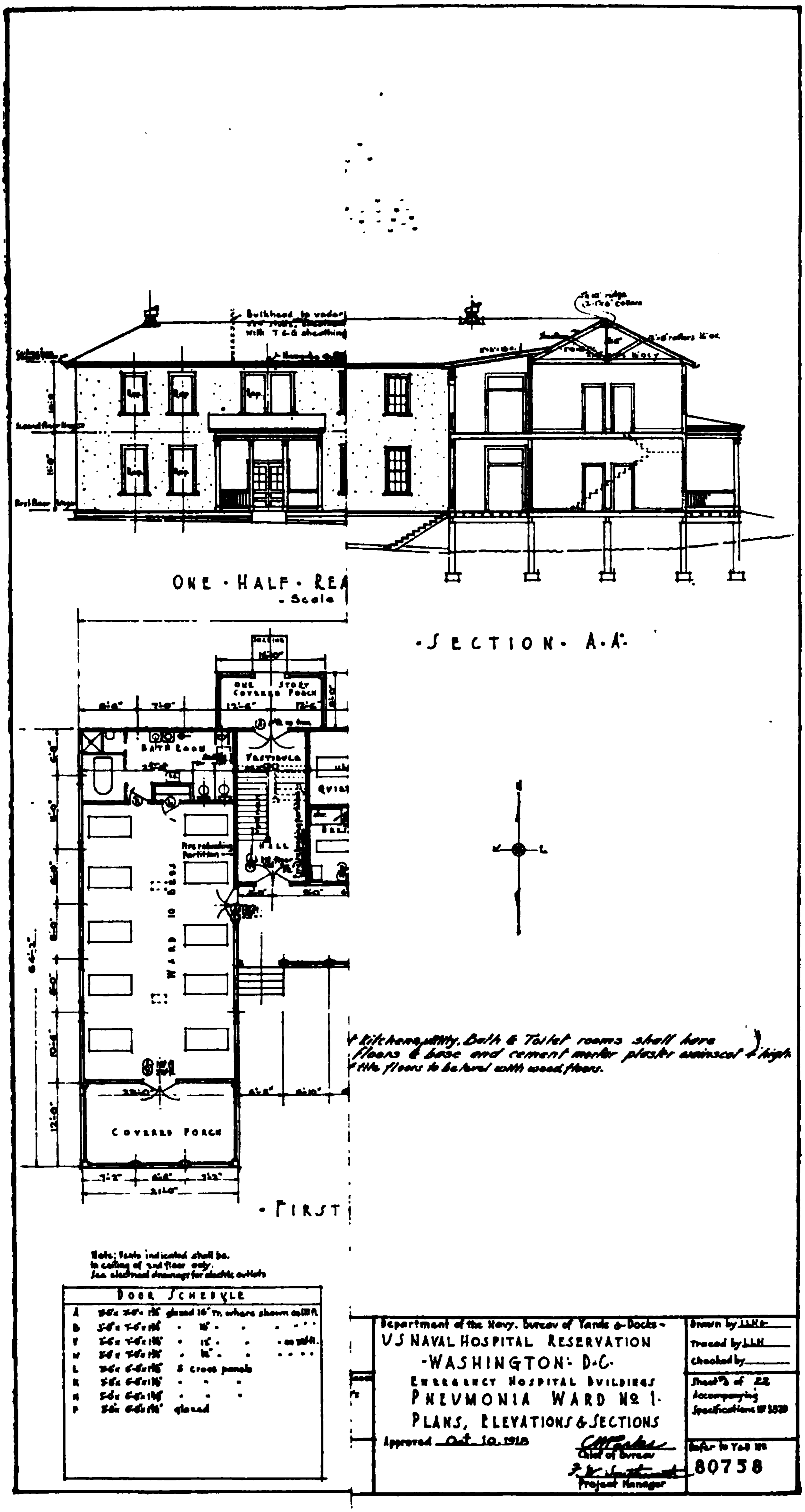
$506.43 each. They were of stock design, with walls wood sheathed inside and outside to provide air spaces. The roofs were protected by a ready-to-lay covering. Two windows were in each side of a building and one in an end. A door was placed in the other end. After November, 1918, some of the portable buildings were salvaged and reused in the United States. These, 54 in number, were sent to the naval hospital at Norfolk, Va., and reerected. After the need for the buildings at Norfolk had passed, some of these were sent to Haiti and to the Dominican Republic for use as field hospitals for the Marine Corps. Others were sent to various hospital reservations. Fifty-one of the 54 were shipped from Norfolk and utilized elsewhere.

The Bureau of Medicine and Surgery started hospitals at 13 overseas stations. For all of these equipment was furnished, and complete laundry machinery and apparatus, including disinfectors, were sent by the Bureau of Yards and Docks to Hospital Bases No. 2 and No. 3. At the time of the signing of the armistice little work had been done under the cognizance of the Bureau of Yards and Docks at some of the hospitals, and at others no work had been completed, but work had been planned for most of the locations. The overseas hospitals were located as follows:

United States naval base hospitals:
- No. 1. Brest, France.
- No. 2. Strathpeffer, Scotland.
- No. 3. Leith, Scotland.
- No. 4. Queenstown, Ireland.
- No. 5. Brest, France.

United States naval hospitals:
- L'Orient, France.
- Pauillac, France.
- London, England.
- Gibraltar.
- Cardiff, Wales.
- Plymouth, England.
- Genoa, Italy.
- Corfu, Greece.

Naval base hospital No. 4, established at Queenstown, Ireland (naval base No. 6), was one of the most complete of those abroad. It was placed in commission November 15, 1918, and provided beds for 200 patients, with provisions for an ultimate capacity of 500. There were quarters for 30 nurses, in addition to barracks for the Hospital Corps men. The reservation contained 11 acres, and was an attractive old estate slightly rolling in its slope to the harbor. The grounds were well planted with trees and shrubs. Fifty portable



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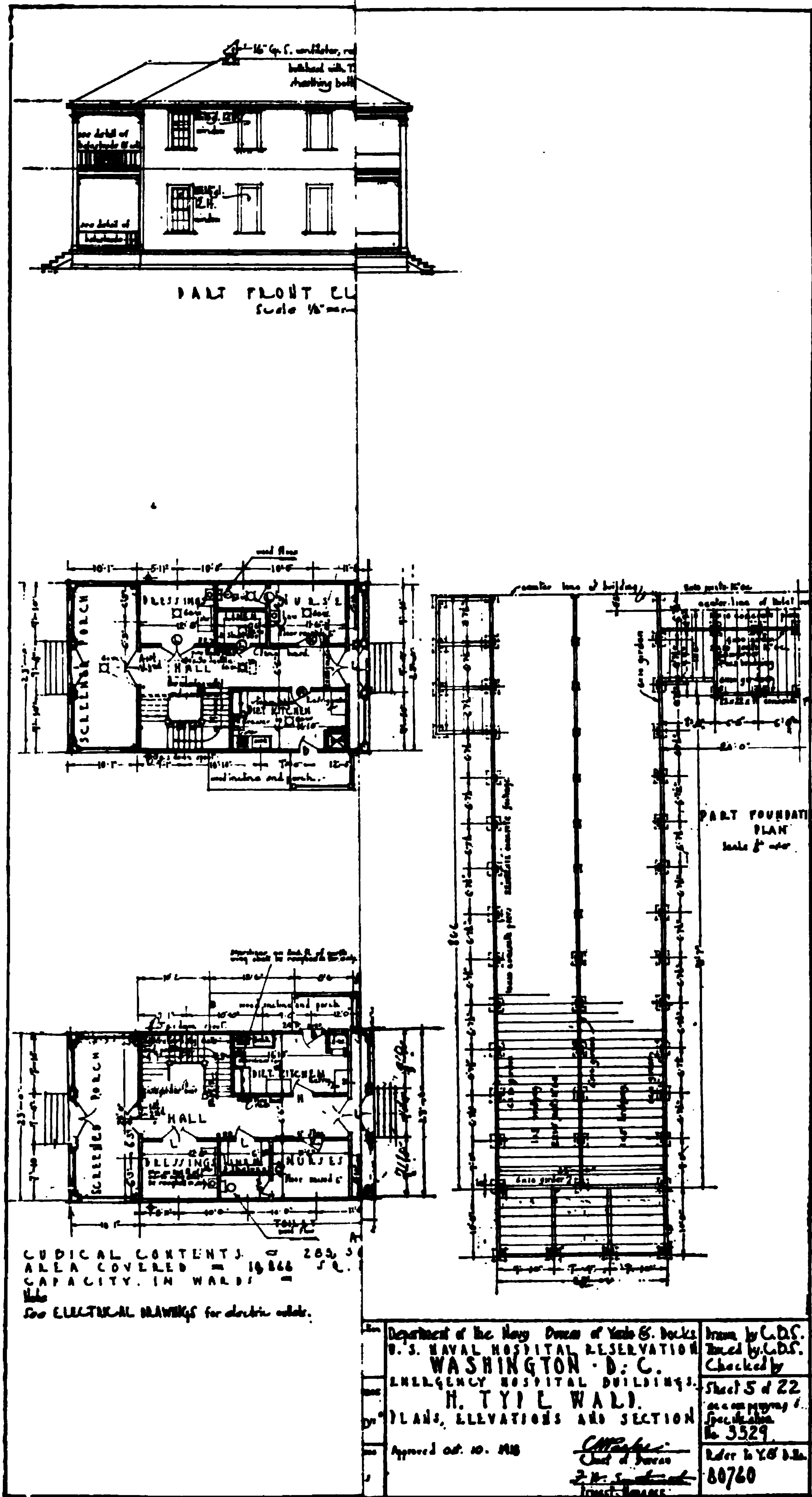
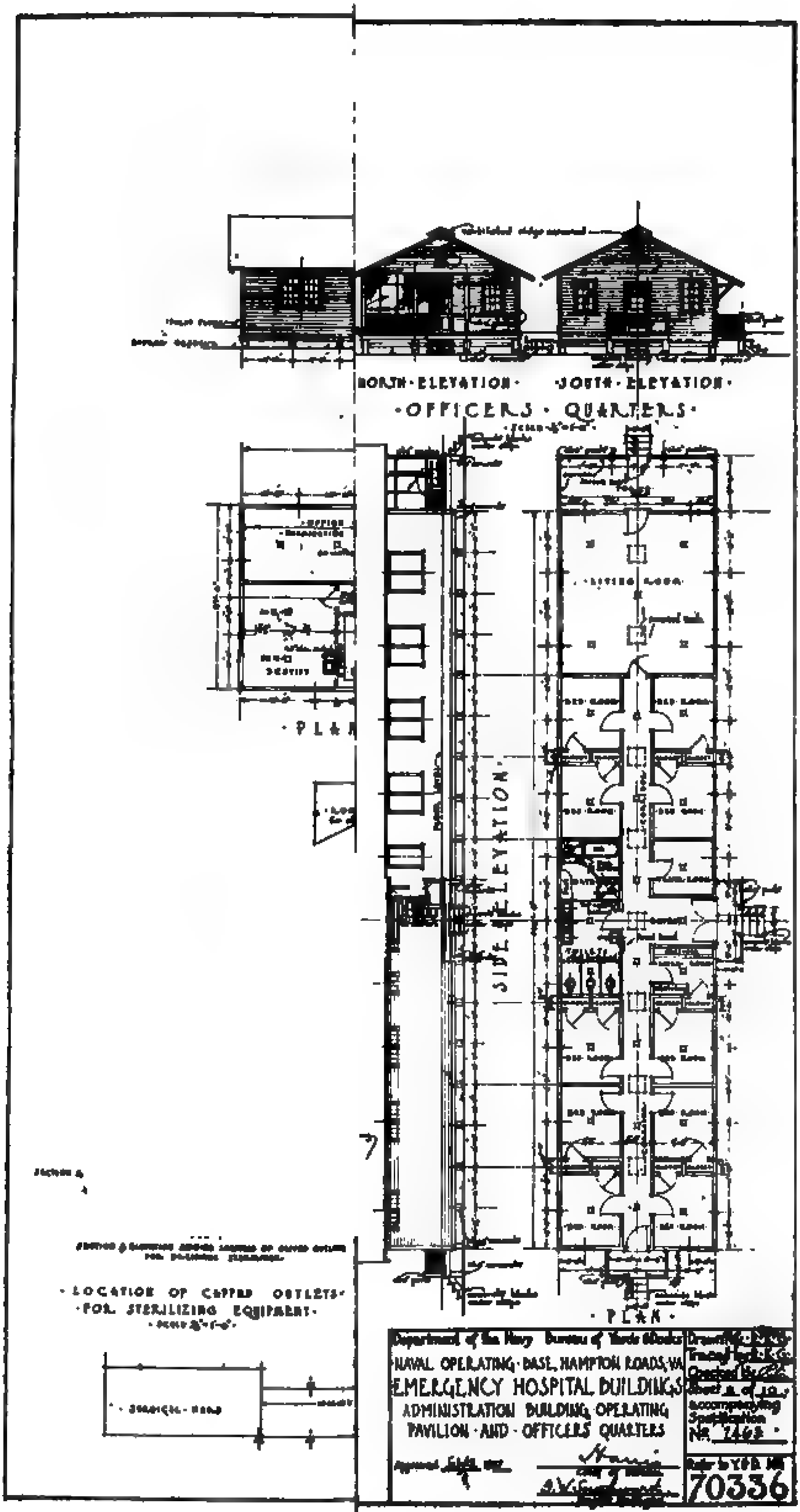
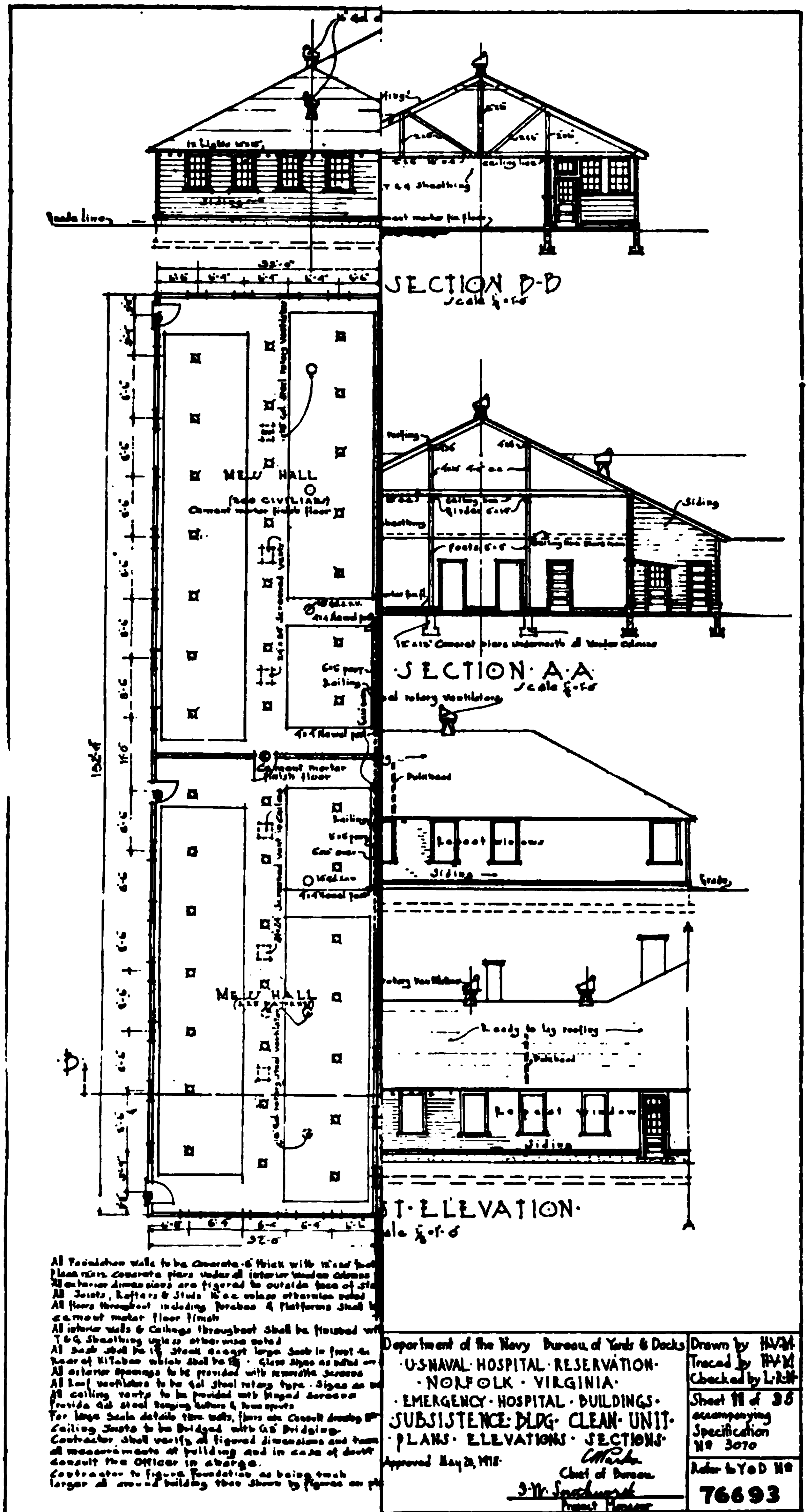

PART FRONT EL
PART FOUNDATION PLAN
SCREENED PORCH
DRESSING
HALL
DIET KITCHEN
NURSES
CUBICAL CONTENTS = 285,3
AREA COVERED = 16,866 SQ.
CAPACITY IN WARDS =
Note
See ELECTRICAL DRAWINGS for electric outlets.
Department of the Navy Bureau of Yards & Docks
U.S. NAVAL HOSPITAL RESERVATION
WASHINGTON · D.C.
EMERGENCY HOSPITAL BUILDINGS.
H. TYPE WARD.
PLANS, ELEVATIONS AND SECTION
Approved oct. 10. 1918
Chief of Bureau
Drawn by C.D.S.
Traced by C.D.S.
Checked by
Sheet 5 of 22
80760


NORTH · ELEVATION ·
· SOUTH · ELEVATION ·
· OFFICERS · QUARTERS ·
· PLAN ·
SIDE ELEVATION
· LOCATION OF CAPPED OUTLETS ·
· FOR STERILIZING EQUIPMENT ·
· PLAN ·
NAVAL OPERATING · BASE, HAMPTON ROADS, VA
EMERGENCY HOSPITAL BUILDINGS
ADMINISTRATION BUILDING · OPERATING
PAVILION · AND · OFFICERS QUARTERS
70336



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buildings 20 by 32 feet, shipped from the United States, and a few of the structures on the grounds, were converted into the hospital group, which consisted of an administration building, operating pavilion, six main wards, three contagious wards, and officers' ward, general mess, Hospital Corps nurses' quarters, storehouse, chapel, morgue, and service buildings. Complete sewer, water, steam heating, fire-protection, electric-lighting, and telephone systems were installed. The hospital, after demobilization of the United States forces, was turned over to the British Admiralty, complete, with all its furnishings and equipment.

The hospital building in London was started by the American Red Cross, and later taken over for hospital purposes for the United States Navy.

A dispensary building with a bed capacity for 38 patients, and with a complete operating and sterilizing suite, was designed for use at Gibraltar. The building was carefully planned and laid out to scale, so that the material for the entire construction, including material for heating and plumbing systems, wiring, and even nails and tools, could be shipped to the site. All materials were cut and fitted previous to crating for shipment. Before these were ready, however, a building was found in Gibraltar that would answer the dispensary needs. Instructions were received from the Bureau of Medicine and Surgery to ship the dispensary to the Azores, but the armistice was signed after the material had been stacked on the pier in Brooklyn for overseas shipment. The building was finally erected on the naval hospital reservation at Norfolk.

The construction of the hospitals at Queenstown, Ireland, and Leith, Scotland, was the only work of this character prosecuted under the local supervision of an officer of the Corps of Civil Engineers. This officer, Lieut. Raymond V. Miller (C. E. C.), U. S. N., with two assistants, Messrs. James E. Gibson and Egbert G. Purdy, enrolled in the Naval Reserve Force as machinists, left New York in April, 1918. The work in connection with these two hospitals had been completed, and arrangements were being made for building a hospital at Corfu, Greece, under the direction of the same officers, when the armistice ended the need for further hospital construction. All of the overseas hospital facilities were rapidly placed out of commission on the return of the American forces.

CHAPTER VII.

GENERAL DEVELOPMENT OF YARDS AND STATIONS.

DEVELOPMENT OF NAVY-YARD PLANS.

Development board.—The naval situation as it took shape in the year 1916, with the six-year building program being formulated, the "preparedness" issue paramount, and the possibility of actual war becoming plainer, foreshadowed an early and unprecedented expansion of navy yards and naval stations, to be superimposed on their normal rate of growth. The year marked an epoch in the history of shore stations as well as of the Navy as a whole. Recognizing the necessity of a comprehensive plan for the development of each of the primary navy yards, so that construction recommended and authorized from time to time might fit in with the general scheme for the finished navy yard, the Secretary of the Navy, on May 2, 1916, appointed a board, known as the Board for the Development of Navy Yard Plans, to draw up for consideration by the bureaus and for his approval a plan for each navy yard. The personnel of this board, with rank as of that date, consisted of Capt. Josiah S. McKean, assistant for material, senior member; Col. John A. Lejeune, representing the Marine Corps; Commander Charles B. McVay, representing Ordnance; Surg. Richmond C. Holcomb, representing Medicine and Surgery; Paymaster Christian J. Peoples, representing Supplies and Accounts; Lieut. Commander George L. Smith, representing Navigation; Lieut. Commander Henry C. Dinger, representing Steam Engineering; Civil Engineer Archibald L. Parsons, representing Yards and Docks, and Naval Constructor Sidney M. Henry, representing Construction and Repair.

The instructions to the board were as follows:

> The board shall prepare for each of the stations listed in the base plan a comprehensive plan of development embodying the requirements of the base plan and the essential features of an ideal layout so far as same may be practicable for the station under consideration. In preparing such plans due consideration shall be given to existing facilities and present arrangements, so that the completed project may be attained with a minimum expenditure.

In order to avoid numerous meetings of the whole board, the assistant for material and the representatives of Yards and Docks, Steam Engineering, and Construction and Repair were appointed a sub-board to develop sketches, plans, etc., for presentation to the

Typical navy yard layout.

whole board. The Bureau of Yards and Docks assigned two draftsmen to this board for the preparation of sketches, plans, estimates, and the like.

Type plan.—The first work which the board undertook was the development of a "type plan" for a navy yard. This plan embodied all the essential features of the shipbuilding and repair yard, consisting of shipbuilding slips, dry docks, a structural shop, a machine shop, foundries, a woodworking shop, storehouses, an administration building, and all of the auxiliary buildings necessary for a well-balanced yard. Considerable study was given to this development with the idea of establishing an ideal or type plan, which was to be used in the development of water-front, docking, shipbuilding, and repair facilities for those navy yards which were selected for expansion for war emergency work, and for the upkeep of the fleet as laid down in the 1916 building program.

After many sketches had been prepared and submitted a preliminary plan of development was selected having the shipbuilding activities at one end of the water front and the dry docks at the other end, with the industrial buildings lying between on a main water-front street. Piers, 1,200 feet long, spaced 300 feet clear, projected perpendicularly from this street and were served by railroad tracks connecting each with all buildings and dry docks. Back of the main water-front street section, all of the auxiliary buildings were indicated. With this so-called ideal plan of development before it (see cut) the board proceeded to the consideration of the requirements of the various yards.

Norfolk plan.—The first yard plan to be undertaken was that for Norfolk, it being necessary to determine the location of the structural shop, appropriation for which was contained in the naval bill of August 29, 1916. After several plans of development had been drawn up by the sub-board, giving full consideration to a plan of water-front development recommended by the Assistant Secretary of the Navy, a plan was finally submitted to the whole board on January 16, 1917. This plan was approved by the whole board and submitted to the Secretary of the Navy, who approved the plan as a basis for future development on February 5, 1917.

Philadelphia plan.—The Philadelphia yard was next taken up, and as many as 20 plans were developed before a final scheme was arrived at. This final scheme was submitted to the whole board in tentative form, and after a few slight modifications was approved and submitted to the Secretary of the Navy for final approval, which was given on May 1, 1917.

Puget Sound plan.—Civil Engineer Gregory, then public works officer of the Puget Sound navy yard, was ordered to Washington for consultation in reference to the development of that yard. He had

prepared for the Commission on Navy Yards and Naval Stations a plan of development which was given consideration by the sub-board, bearing in mind the previously prepared development plans for Norfolk and Philadelphia. After several additions to and relocations of water-front structures had been made, a plan was adopted and submitted to the whole board, which approved the sub-board's plan and submitted same to the Secretary of the Navy, the plan being approved on May 25, 1917. Two additions to this plan have been made and approved, one showing the development of the northeast corner for the storage of structural steel, on November 30, 1918; and the second, designating the area directly north of dry dock No. 2 for a foundry and the area south of the officers' quarters for a forge shop, on February 11, 1919.

Naval operating base, Hampton Roads.—After the Puget Sound yard plan had been approved, the members' attention was given to the proposed naval operating base, Hampton Roads, Va. This property, comprising the old Jamestown Exposition site and the Pine Beach Hotel property, was offered as a site. The board, after studying the requirements of a naval operating base, tentatively fixed the areas to be set aside for each activity, namely, aviation, recruit training station, submarine base, and fleet supply base. The tentative assignment of space for these activities received the Secretary's approval in the early part of June, 1917, and plans were begun for the development of the training station, active construction of which started on July 4, 1917.

Pacific stations.—After the approval of the naval operating base plans, the board ceased to function, owing to war activities, until March 7, 1919, when it reconvened and gave consideration to the development of stations on the Pacific. Plans for Pearl Harbor, Guam, and Cavite are now under consideration.

DEVELOPMENTS UNDERTAKEN.

The more important general development projects undertaken at the various yards and stations are covered, by locations, below:

NAVAL OPERATING BASE, HAMPTON ROADS, VA.

Necessity.—War having been declared, it was seen that the projected base at Hampton Roads would have to be developed as an emergency measure rather than by the conventional method of growth, in order that fleet operations might be supported at the earliest opportunity by the facilities of this magnificent location, with its many natural and artificial advantages.

Site.—Two sites were proposed for this operating base—one on the York River in the vicinity of Yorktown, the other on the former Jamestown Exposition site at Sewalls Point, fronting on the Eliza-

West bulkhead before filling, Naval Operating Base, Hampton Roads, Va.

Filling behind bulkhead, Naval Operating Base, Hampton Roads, Va.

Bulkheads along Boush Creek, Naval Operating Base, Hampton Roads, Va.

Bulkheads for aviation pier, Naval Operating Base, Hampton Roads, Va.

beth River and Willoughby Bay. After much discussion as to the advantages and disadvantages of both sites, Sewalls Point was finally selected and the land commandeered by the Secretary of the Navy for immediate development, under Presidential proclamation dated June 28, 1917. Under this proclamation the President set aside the sum of $1,200,000 as payment for said property, and the sum of $1,600,000 toward the development of the base, including piers, storehouses, fuel-oil storage, a training station, and recreation grounds for the fleet personnel.

The land taken over comprised approximately 474 acres, 367 of which were occupied by the old Jamestown Exposition grounds, 100.8 acres by the Pine Beach estate, and 6 acres by Maryland Avenue, a thoroughfare dividing the two sections of the property. Of the grand total, 397.6 acres were high ground and 70.1 acres ground outside of the well-defined high-water line.

The property, when taken over, was very densely covered with underbrush, and the improvements constructed during the Jamestown Exposition were in a very poor state of repair. The section to the west of Maryland Avenue, the Pine Beach area, was occupied by a negro settlement known as White City. The buildings comprising this settlement were of the typical southern negro shanty type, there being a few buildings of a more pretentious nature in the way of hotels used during the exposition time, and a few small stores. All of the temporary buildings of the Jamestown Exposition had been removed, and there remained on the site only the central group, comprising the auditorium building, the Hall of History, and a number of the State buildings.

At the extreme east of the exposition site, in the district east of Commonwealth Avenue, quite a number of houses had been erected by private owners. This district had been subdivided by real estate operators and the lots sold off to numerous private individuals. The houses which were constructed were of a simple character and had very little relation to the general development of the subdivision.

A board appointed to fix the value of the property within the site selected for the naval operating base, in accordance with the provision of the act of June 15, 1917, reported the value of the property to be $1,422,935. The assessed value of the property was $362,117.13. The amount asked for the property and improvements by the numerous owners was $3,009,935.56. Of this latter amount $1,909,647.26 was the asked price for that portion of the property known as the exposition site, and $1,057,988.30 for the portion known as the Pine Beach site.

Initial construction.—The war was on and the need for trained men was urgent. The recruits must have their first training on

shore, and to give it training camps must be provided. The occupants of the site were immediately (on June 28, 1917) notified to vacate, they being given a period of 30 days to vacate the property. Active construction work on the training-camp section, as a facility urgently needed and susceptible of immediate development, began on July 4, 1917, under the direction of Capt. F. T. Chambers (C. E. C.), U. S. N., and four civilian assistants from the Bureau of Yards and Docks, Messrs. Sinclair, Duba, Burke, and Grimes. Within a period of 30 days housing for 7,500 men had been constructed, consisting of barracks buildings, mess halls, lavatory buildings, storehouses, and the necessary auxiliary construction, including water systems, lighting, roads, and walks. This also necessitated the construction of approximately 3 miles of standard-gauge railroad to afford access to the base, the clearing of approximately 400 acres of ground thickly covered with underbrush, and the development of a system of roads to connect the development with the county-road system of Norfolk.

The transportation problem at the beginning of the operations was very difficult; the only solution, in the early stages, the roads being impassable to motor equipment, lay in transporting all construction material from the nearest railroad siding, approximately 1½ miles distant, by horse-drawn vehicles carrying only half loads. It was necessary to work these teams in two shifts in order to avoid delay to the work. Excessive rains during the first two weeks of construction also tended to impede the work, but in spite of impassable roads, inclement weather, and mud, the work of constructing the training camp was very successfully carried out. (See chapter, "Training Camps.")

Water-front improvements, etc.—The next portion of the base to receive attention was the water front. It was realized that the available land was insufficient for the requirements, and it was therefore decided to bulkhead and fill a large portion of the flats lying to the west and north of the property by dredging to a sufficent depth to allow capital ships to berth at piers to be constructed on the west water front, and to a sufficient depth for seaplanes and small craft on the north and east fronts. The material thus dredged provided sufficient fill to create an area of new land nearly equal to that in the original tract, making the new total area approximately 792.93 acres. For the west front, the plan contemplated six piers, each 125 feet wide and 1,400 feet long, with 300-foot slips, beginning 200 feet from the south reservation line. Of these piers, two directly opposite the supply base (Nos. 2 and 3), have been constructed. The northerly 1,200 feet of this water front were assigned to the submarine base, which is described more fully elsewhere. The inclosed area behind

Merchandise pier, Naval Operating Base, Hampton Roads, Va. Bulkhead fill not made.

Pier No. 3, Naval Operating Base, Hampton Roads, Va.

Aviation station, Naval Operating Base, Hampton Roads, Va., showing utilization of former exposition lagoon.

Concrete sheet-pile protection of existing bulkhead walls of lagoon, Naval Operating Base, Hampton Roads, Va.

the north bulkhead, to the east of the center of the reservation, was assigned for lighter-than-air aviation activities, while the area at the extreme east, including the spit of land (also inclosed by bulkheads and filled and enlarged), was assigned for heavier-than-air aviation.

The total length of bulkhead, constructed to inclose flat lands offshore, was 22,150 linear feet. The work of constructing this bulkhead, with the 10 timber piers, inclosing bulkhead, and main pier of the submarine base, and merchandise pier No. 2, was divided between two contractors—James Steware & Co., of New York, constructing the merchandise pier, 9,250 feet of the inclosing bulkheads, and the main submarine base pier, and H. P. Converse & Co. constructing the submarine piers, the inclosing bulkhead of the submarine basin, and 12,900 feet of the inclosing bulkheads on that portion to the east of the lagoon on the north front. The work on these contracts was done during the fall and winter of one of the severest seasons experienced in the Hampton Roads region, the Roads being frozen from shore to shore for a considerable portion of January and February of 1918, and it being impossible to operate water equipment during a great portion of this time. Severe blows accompanied by extreme cold weather were experienced during the greater part of the winter. The contracting companies displayed great energy in constructing this work, and the job was very successfully completed under extremely difficult conditions. The amount of money expended on these contracts was $3,104,281.28.

Approximately 8,000,000 yards of dredging was performed on the various fronts—in the submarine basin, alongside the merchandise piers, and in front of the bulkheads to the west and east; there were also dredged a channel into Bush Creek for training-station vessels, and a large deploying space in front of the aviation section for seaplanes. This work was performed by two contractors at a total cost of about $2,373,000. The material was moved entirely by suction dredges, which pumped through pipe lines to the areas behind the bulkheads until the elevation had been raised to 10 feet above low water. The material pumped varied in nature from a sandy soil that drained in a comparatively short time without serious settlement, making part of the new land generally available for improvement without delay, to mud, clay, and silt.

The water area inclosed within the old Government pier, built at the time of the Jamestown Exposition, was used during the early activities at Hampton Roads for aviation. Temporary wooden hangars, shop buildings, and an office building were constructed just inshore from the end of the pier, and two hangars and a launching pier on the outboard end.

There also remained standing, along the water front to the east and west of the central exhibition group, a row of the buildings once

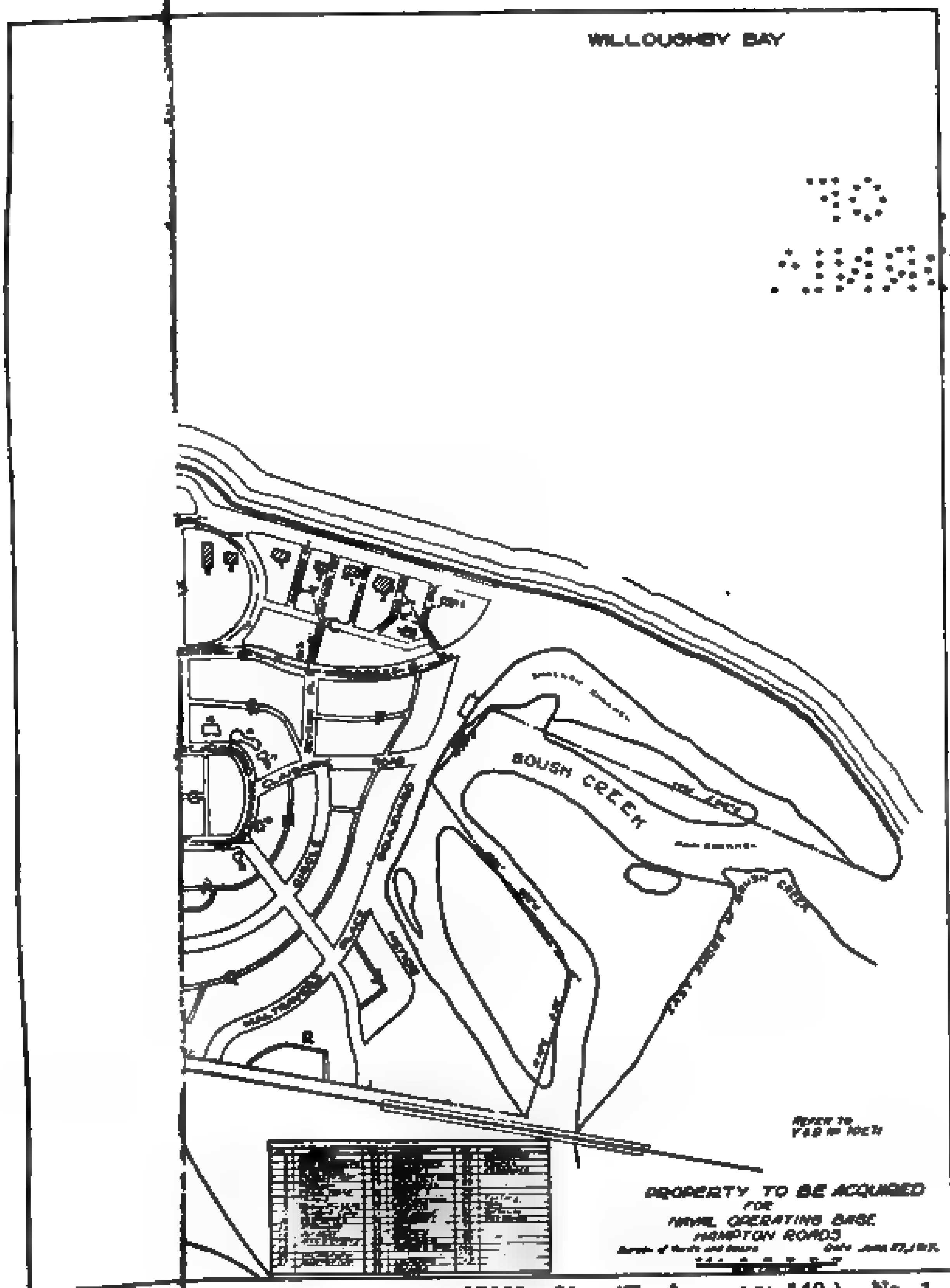
used for State exhibits. These were of a permanent character and were converted into officers' quarters. A considerable amount of money was expended for this purpose, and also for rehabilitating the central group of exposition buildings, the main building being converted into an auditorium, with district and base administration offices in either wing. The old History Building was used during the construction period as a public works office building, and later used as an armory.

The general layout of the grounds as it existed during the exposition period was maintained as far as possible, the water and sewer systems being made use of to their fullest extent and repaired where necessary. The streets were maintained, and all building construction laid out so as to conform as nearly as possible to the former layout. On account of the flat nature of the entire area, some difficulty was experienced with surface drainage, and considerable sums were necessarily expended for this purpose. During the early period of construction, an important project in itself was the erection of a 10-foot nonclimbable wire fence along the entire boundary line from mean low water on the Elizabeth River to mean low water in Boush Creek. This fence was approximately one and one-half miles in length.

The transportation difficulties for workmen employed by the contractors were overcome in the early stages of operation by the base authorities' insistence upon the placing of sufficient cars on the Pine Beach run to enable the workmen to be transported to and from Norfolk, a distance of approximately 7 miles. After numerous conferences, the Norfolk traction officials consented to increase the service on this line to accommodate 7,000 workmen who were employed during the construction period.

The railroad connection to the base was an item provided under a serious handicap. At the time of beginning of work there was a stub-end railroad at approximately one-quarter of a mile from the boundary line of the naval base, this track being adjacent to the roundhouse of the Virginian Railway. There being no Government railroad material immediately available, nor labor skilled in this class of work, the cooperation of the Virginian Railway in the furnishing of material and foremen was secured. A spur track was then built for a distance of approximately 3 miles into the base. The railroad connection was, of course, essential both to the construction and subsequent operation of the base. Since the initial railroad connection was made, over 9 miles of railroad have been constructed within the reservation.

There is attached hereto a plan showing the site of the operating base on June 27, 1917, and also one representing conditions existing on July 1, 1920, which drawings will quite clearly indicate the magni-



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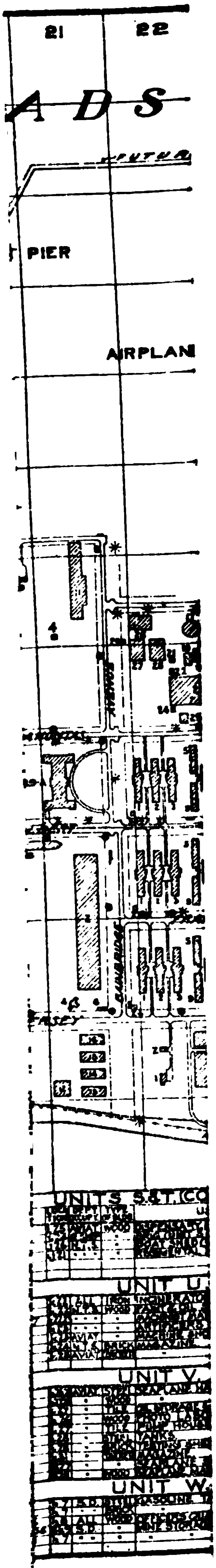


o 1920.

Schmoele tract, Navy Yard, Norfolk, Va., before development.

Schmoele tract, Navy Yard, Norfolk, Va., after development.

Quay wall construction, Navy Yard, Norfolk, Va. Jetting of concrete sheet piles in foreground.

Construction of concrete retaining wall, Navy Yord, Norfolk, Va.

tude of the base and the volume of the work accomplished during the three years of Government occupation. The development to date includes two training camps, for 14,000 men each, the aviation base, with a flying field and four large seaplane hangars and miscellaneous buildings and facilities, the submarine base for 31 boats, and the supply base with its nearly 2,000,000 square feet of covered storage area. The component parts of this great naval base are covered, more in detail, under the various particular headings.

NAVY YARD, NORFOLK, VA.

The principal development work at the Norfolk yard consisted of the new 1,000-foot dry dock and the building up of a new shipbuilding and industrial plant on the low marsh-land adjoining the yard and known as the "Schmoele tract." The construction of this large dry dock and of the various shops, building ways, and water-front improvements of the industrial development are described in their appropriate chapters. The power and power distribution development made necessary by this great expansion is also discussed elsewhere.

NAVY YARD, PHILADELPHIA, PA.

The development work laid out for the Philadelphia yard was of a more general nature and covered almost the entire reservation. In addition to the dry dock and the shipbuilding and power plant developments, described under those general headings, the yard's storage facilities, permanent and temporary, were increased manyfold; Marine Corps, training camp, and hospital reservations have been developed to a great extent; and a new naval aircraft factory was constructed and placed in operation in record time. All of these improvements are covered in greater detail under the respective general headings. As a result of the various improvements, the developed area of this yard is now approximately 280 acres, practically double the corresponding area of 1916.

NAVY YARD, NEW YORK.

At the New York yard, because of its restricted space, the development has been almost entirely for shipbuilding and industrial purposes; the shipbuilding and repair shops, ways, etc., are covered under that general heading, and the large 11-story general storehouse and several temporary storehouses are dealt with under the heading "storage facilities."

To provide the necessary space, as well as to provide properly for these activities themselves, it was necessary to eliminate from the

View looking east from radio tower, Navy Yard, Philadelphia, Pa.

View looking west from radio tower, Navy Yard, Philadelphia, Pa.

Structural shop and shipbuilding slips, Navy Yard, Philadelphia, Pa. Dry Dock No. 3 in foreground.

yard some of its former activities, such as fleet supply, provisions and clothing handling, etc., to commandeered property and to the new fleet-supply base, South Brooklyn.

NAVY YARD, PUGET SOUND, WASH.

The following discussion of the development of the Puget Sound yard is based on the personal account of Capt. L. E. Gregory, the civil engineer officer in charge of public works at that point from 1913 to 1920, inclusive:

Preliminary.—The necessity for modernizing this yard in many important particulars was early seen, and a close study of the yard's needs was made by the public works officer in conjunction with the heads of other yard divisions and departments. Several board reports were submitted at different times, but by far the most complete and comprehensive was that submitted in the latter part of 1916, under the direction of the commandant of the station, Admiral (then Captain) Robert E. Coontz, U. S. N. As the World War had been in progress for some time, these studies were naturally made in a very thorough manner, and it was with great satisfaction that the officers of the yard noted that these plans were singularly in harmony with the ideal yard-development plan prepared by the Development Board. The Commission on Navy Yards and Naval Stations (the "Helm commission") arrived at the yard on January 6, 1917, when it was found that the yard officers had been working along lines which coincided to a very marked degree with the commission's views.

Only the day before the commission's arrival the yard received notice that it had been selected as one of those to be developed for shipbuilding purposes, and that an award had been made to it for the construction of ways for the building of an ammunition ship for the fleet. The Helm commission left the yard on February 3, 1917, and it was subsequently learned that it had made recommendations for the expenditure of large sums of money, with a view to extending the yard's facilities to a very marked degree in all phases, it being realized that at Puget Sound there should be developed a naval station of the first class.

Important work was undertaken during the war toward increasing the facilities for shipbuilding and storage, and also for the encampment of naval recruits. These matters are detailed in other chapters.

Bremerton water supply.—The yard was dependent upon the Bremerton municipal water company for its fresh-water supply, and early in 1917 it was realized that the very unsatisfactory condition of this supply was a grave menace to the yard. The system had shortly before been taken over by the city of Bremerton, and as negotiations had been pending for several years, the former owners had refrained from making expenditures for improvements to the plant. While this supply had ample quantity at its source, the main from source to town was of wood, very old, and subject to frequent breaks, which often cut off the town completely from service. The navy yard had secured itself against disaster by installing reservoir capacity within the yard proper, aggregating about 2,600,000 gallons, which would tide it over several days of isolation from outside supply, but in the event of a complete breakdown of the Bremerton plant, this resource would have been unavailing. It was realized, therefore, that Bremerton should not only improve its pumping plant and its mains but

Filling operation in progress, Navy Yard, Puget Sound, Wash.

Filling operation in progress, Navy Yard, Puget Sound, Wash., showing extension of shore line.

Grading and filling operations, Navy Yard, Puget Sound, Wash. General view.

Grading operation completed, Navy Yard, Puget Sound, Wash. Slope protection

should also have a reservoir capacity of approximately 10,000,000 gallons closer to the town. Accordingly, on May 22, 1917, a conference was held in the office of Admiral Coontz, the commandant, with the mayor of Bremerton, the city engineer, and the public works officer, to discuss ways and means. It was decided that Bremerton should make improvements along the lines above noted, and this work was pushed with intelligence and zeal. Within a few months the city had available a water supply which was able to meet a growth which could not have been anticipated and which was far in excess of any that had occurred for many years prior thereto. Increasing activities of the navy yard, together with the great increase in housing facilities throughout the city, more than doubled the water consumption and justified the large expenditure entailed upon the city. The public works officer acted as consulting engineer on this work without compensation.

Government housing.—Bremerton came in for substantial recognition by the United States Housing Corporation, and conferences were held, beginning in March of 1918, between representatives of the housing corporation and the yard authorities. The need for housing in connection with yard activities was urgent, and a very successful program was carried out. This is covered more fully in the proper chapter.

General.—Reference is here made to the visit of the public works officer to Washington early in 1917, in connection with the plans being formulated for navy yard development. In view of the detailed studies he had made on this question during a period of several years preceding, he was able to render the bureau considerable assistance in working up the official plan for Puget Sound. Such a plan was finally evolved and was approved by the Secretary of the Navy in the latter part of May, 1917. It has since been followed with but slight modifications. One of the principal features of this development was the making available for building purposes of a very considerable tract of high, undulating land in the central portion of the yard in front of the quarters, which had been usable for many years only as golf links, and during the war was made use of for the temporary training camp. The idea was conceived of grading down this land to the industrial yard level and utilizing the soil in filling along the water front. The building area of the yard was thereby increased in a twofold manner by making available land areas previously too high for use and by utilizing the waste material in filling areas previously submerged and bringing this fill up to level. The area of land to be gained in this development was approximately 120 acres. The idea of this development was suggested by the public works officer, and was embodied in a contract made in 1918. This contract, involving the excavation and deposit of about 2,000,000 cubic yards of earth, comprised the first and largest portion of the grading operation, and has now been completed. The plan as a whole contemplates the construction of a concrete sea wall along the entire new front, but lack of funds has precluded the latter undertaking as yet. The work already done was performed under contract.

Further increases of land were made by purchases of three separate areas, one along the water front at the easterly end of the yard, aggregating about 7 acres, including tide lands and uplands, and extending the length of the water front about 800 feet; another small area of about six-tenths of an acre at the northeast corner of the yard, providing storage space for steel, adjacent to the shipfitters' shop; also an area of 20 acres at the northwest corner of the yard, designed to be used for military or storehouse purposes. The public works officer conducted all of the preliminary negotiations with owners and rendered assistance to the Board on Condemnation of Land, which had its hearings in Bremerton in the latter part of 1919.

NAVY YARD, MARE ISLAND, CALIF.

The development at Mare Island included shipbuilding and repair facilities, storage facilities, a training camp, and hospital and submarine base projects covered under those respective headings.

Another project that has been completed, of considerable importance to this yard, is the causeway connecting the yard with the mainland at the city of Vallejo. Prior to its completion all railroad freight was received at and shipped from Mare Island by means of car floats, and on account of the slow service and high freight charges resulting from this method of handling, the need of a direct railroad, as well as highway, connection had long been recognized. With the great increase in volume of freight during the war, this situation became acute, and accordingly, in order to eliminate costly delays and to save thousands of dollars in freight rates annually, the construction of the causeway was authorized and carried out under funds allotted from the appropriation "Emergency expenses."

During the year 1918 several preliminary studies were made by the yard for the connection of the tracks of the causeway and of the yard with those of the Southern Pacific system, and estimates were submitted to Congress to cover this part of the project. As a result there was made available, in the naval act of July 11, 1919, the sum of $165,000 to cover the purchase of right of way and the construction of the railroad connection between the causeway tracks and the South Vallejo railroad yards. Direct rail connection has been made to the yard over the causeway by agreement with two electric railroads—the San Francisco, Napa & Calistoga, and the Sacramento Northern.

The causeway itself is of timber pile trestle construction, and provides a single standard-gauge railroad track, an 8-foot sidewalk, and a roadway 20 feet wide. The over-all width of the causeway is 40 to 44 feet, and its length about 3,000 feet. A steel bascule bridge of an 80-foot clear span is provided at the crossing of the channel to allow the passage of vessels through the strait. The electrification work consisted of the installation of an overhead-wire system in accordance with the standards of the operating company, the San Francisco, Napa & Calistoga Railway.

The causeway was constructed under contract; the wye tracks and classification yard by yard labor; and the electrification work under contract with the San Francisco, Napa & Calistoga Railway.

NAVY YARD, PORTSMOUTH, N. H.

The general development projects at this yard have, comparatively speaking, not been extensive. The yard was equipped for building submarines and carried that work on actively.

Causeway connecting Mare Island Navy Yard with mainland.

Causeway connecting Mare Island Navy Yard with mainland; bascule bridge raised.

Concrete retaining wall for pier, Naval Air Station, Pensacola, Fla

Pier, Naval Air Station, Pensacola, Fla. Dredging and filling in progress.

NAVAL AIR STATION, PENSACOLA, FLA.

The navy yards at which important development work of a general character has been carried out have now been reviewed. A number of important general development projects at various naval stations are still to be mentioned.

The principal development of the Pensacola station has been for purposes connected with aviation, but in order to provide needed berthing facilities for supply vessels and others and to replace the old timber wharves destroyed by storm in July, 1916, a pier, 60 by 580 feet, and 1,600 linear feet of quay wall were constructed. This work is of the same permanent type as the fitting-out pier and quay walls at the Norfolk navy yard (described under "Shipbuilding and repair facilities"), namely, the relieving-platform type with concrete sheet piles and walls, the depth of water in this case being 30 feet.

NAVAL TRAINING STATION, GREAT LAKES, ILL.

The training camp development at the Great Lakes station is described elsewhere in this volume.

The naval appropriation act of July 11, 1919, contained an item authorizing an extensive shore protection and harbor development project for this station. Under this authorization, shore protection work, along the northerly part of the water front, has been very successfully completed by station forces, and plans and specifications have been developed to cover the pier, quay walls, breakwaters, and dredging and filling required for the harbor development.

The shore protection work performed consisted of a series of 18 rock-filled timber-crib groins, spaced 200 feet on centers, and placed at right angles to and extending about 90 to 155 feet out from the shore, in order to arrest the scouring of the shore by littoral currents, and to facilitate the formation of a protective beach by the deposition of the sand carried. In connection with this part of the project, steps have also been taken for the protection from erosion of the bluffs along the water front, by means of depositing heavy protective material at critical points.

The entire project, when completed, will provide a harbor nearly half a mile in length and width, with a 20-foot depth of water, protected by over a mile of breakwater. The development inside the harbor will ultimately include a pier 50 by about 700 feet, about 2,000 feet of quay wall, and a 90-ton marine railway. The latter, as noted elsewhere, will be erected of material originally purchased for shipment to Corfu, Greece, but held in this country upon the signing of the armistice.

PROPOSED NAVAL BASE, SAN FRANCISCO BAY.

Pursuant to the recommendations of the final report to the President of the Commission on Navy Yards and Naval Stations, on the proposed additional navy yard on the Pacific coast (dated September 29, 1917), further studies and estimates have been made with a view to determining the relative advantages of the three recommended sites on San Francisco Bay (Alameda, Hunters Point, and Carquinez Strait). The work of completing additional subsurface exploration of these sites, in order definitely to ascertain conditions and difficulties that might be expected in the course of the construction of the foundations of the various dry docks, waterfront structures, and buildings at each of the three sites, has been expedited in order that final recommendations as to site may be placed before Congress.

MOORING FACILITIES.

On account of the great increase in the number of ships of all classes during the war, it has been necessary to increase the mooring facilities at the various stations. Because of the formation of the large Pacific Fleet, the demand for such facilities has been particularly urgent at stations on the Pacific coast.

In spite of the very limited funds available for such projects, a considerable number of moorings have been provided; these facilities are of types in accordance with the type of vessels to be moored, conditions at sites, and funds available. They range from dolphins and small can buoys to the large communication buoys used for flagship moorings.

CHAPTER VIII.

SHIPBUILDING AND REPAIR FACILITIES.

GENERAL CONDITIONS—IMPROVING AND EQUIPPING OF NAVY YARDS FOR THE CONSTRUCTION OF SHIPS.

Necessity for improvements.—One of the most important provisions of the Navy Department's preparedness program of 1916 was that for increased facilities for the construction of ships, particularly capital ships, at the Navy's own yards. Prior to that time adequate plant for the construction of large battleships was limited to two navy yards and a few privately-owned shipyards. The proposed construction of battle cruisers longer by over 200 feet than any battleships previously laid down, and of larger and heavier battleships, necessitated the remodeling and extending of such building facilities as were already available. The decision was also reached at this time to increase and improve the facilities for the construction of smaller vessels—auxiliaries, destroyers, gunboats, and submarines.

Inception.—Actual progress on the program for the improvement of building facilities, and incidentally repair facilities, was started by Congress in the naval appropriation act of August 29, 1916, when $6,000,000 was made available for the improving and equipping of the navy yards at Puget Sound, Philadelphia, Norfolk, New York, Boston, Portsmouth, Charleston, and New Orleans for the construction of ships, the Norfolk, Philadelphia, Boston, and Puget Sound yards being designated for the construction of capital ships. The naval act of March 4, 1917, carried an additional $12,000,000 for this purpose, to be used in the event of the Secretary of the Navy being unable to secure from private shipbuilders contracts for the expeditious and economical construction of the ships authorized. The deficiency act of March 28, 1918, and the naval act of July 1, 1918, carried further appropriations of $1,570,000 and $10,000,000, respectively, for these improvements.

During the progress of the work a number of additional appropriations were made by Congress, both to cover unprecedented increases in cost of construction work over costs prevailing when preliminary estimates were made, and to cover specific projects relating to the shipbuilding improvements. A tabulation of the principal

appropriations covering shipbuilding and repair facilities (exclusive of dry docks) follows:

Principal appropriations for shipbuilding and repair facilities (exclusive of dry docks).

Date of approval of act.	Appropriation.		Subhead.		Amount.
	No.	Title.	No.	Title.	
Aug. 29, 1916	124	Improving and equipping of navy yards for the construction of ships.			$6,000,000
Mar. 4, 1917	124	.....do.....			12,000,000
Mar. 28, 1918	124	.....do.....			1,570,000
July 1, 1918	124	.....do.....			10,000,000
Oct. 6, 1917	294	Handling appliances			450,000
	296	Marine railways			375,000
Mar. 4, 1917	215	Navy Yard, Portsmouth.	161	Crane track extension	11,000
July 1, 1918	215	.....do.....	164	Addition to machine shop	200,000
	215	.....do.....	165	Addition to foundry	130,000
June 4, 1920	215	.....do.....	169	Welding shop	15,000
Mar. 4, 1917	216	Navy Yard, Boston	191	Extension, chain shop	60,000
July 1, 1918	216	.....do.....	194	Machine shop and foundry	900,000
July 11, 1919	216	.....do.....	196	25-ton floating derricks	40,000
Mar. 4, 1917	218	Navy Yard, New York	228	Remodeling building 132 for pattern shop.	34,000
	218	.....do.....	230	Machine shop extension	400,000
July 1, 1918	218	.....do.....	231	Water-front improvements	750,000
June 4, 1920	218	.....do.....	236	Steel storage, crane runway, and cranes.	200,000
	218	.....do.....	237	Two cranes for building slips	100,000
Mar. 4, 1917	219	Navy Yard, Philadelphia.	203	50-ton locomotive crane	100,000
July 1, 1918	219	.....do.....	207	Tracks, streets, and sewers	100,000
July 11, 1919	219	.....do.....	211	Paving, tracks, sewers, etc	100,000
	219	.....do.....	212	Mattress and life-preserver factory	100,000
	219	.....do.....	213	Pattern shop and storage	400,000
June 4, 1920	219	.....do.....	216	Two cranes for building slips	100,000
Aug. 29, 1916	221	Navy Yard, Norfolk	221	150-ton floating crane	265,000
	221	.....do.....	223	Structural shop	400,000
Mar. 4, 1917	221	.....do.....	226	.....do.....	600,000
	221	.....do.....	227	Water-front improvements	500,000
July 1, 1918	221	.....do.....	230	.....do.....	500,000
July 11, 1919	221	.....do.....	236	.....do.....	500,000
June 4, 1920	221	.....do.....	246	.....do.....	250,000
July 1, 1918	221	.....do.....	232	Streets, tracks, and sewers	150,000
July 11, 1919	221	.....do.....	237	.....do.....	100,000
July 1, 1918	221	.....do.....	233	Galvanizing shop	100,000
	221	.....do.....	234	Steel storage	400,000
June 4, 1920	221	.....do.....	244	.....do.....	220,000
July 11, 1919	221	.....do.....	238	Auxiliary fitting-out cranes	100,000
	221	.....do.....	239	Grading Schmoele tract	25,000
	221	.....do.....	242	Pattern shop and storage	400,000
June 4, 1920	221	.....do.....	245	Crane for building slip	50,000
July 1, 1918	222	Navy Yard, Charleston	113	Water-front improvements	200,000
July 11, 1919	222	.....do.....	118	Oxy-acetylene plant	15,000
Aug. 29, 1916	226	Navy Yard, Mare Island.	220	Floating crane	300,000
Mar. 4, 1917	226	.....do.....	221	.....do.....	450,000
July 1, 1918	226	.....do.....	226	Structural shop and auxiliary improvements.	1,000,000
Nov. 4, 1918	226	.....do.....	226	.....do.....	1,500,000
July 11, 1919	227	Navy Yard, Puget Sound	226	20-ton floating crane	50,000
June 4, 1920	232	Naval Station, Pearl Harbor.	76	Machine shop	100,000
	232	.....do.....	78	Oxy-acetylene building	15,000
	232	.....do.....	79	Marine railway	200,000
July 1, 1918	274	Naval Fuel Depot, San Diego.	1	.....do.....	175,000
June 4, 1920	274	.....do.....	2	Relocation and increased capacity, marine railway, and additional shore facilities at repair base.	750,000
		Total			43,549,000

In addition to these appropriations, allotments, totaling several millions of dollars, to cover projects allied to or forming part of the shipbuilding program were made from appropriations "Naval

emergency fund," "Emergency expenses," "Repairs and preservation," and "Contingent," and from general and specific appropriations for the improvement of power plants and distributing systems.

General program.—The schedule for the apportionment of the first two appropriations for shipbuilding facilities was worked up in correspondence and conferences between the department and the various bureaus and yards concerned. The schedule approved by the department provided for improvement at the Portsmouth yard for the construction of additional submarines, minor improvements at the Boston yard for the continued construction of auxiliaries, the equipment of the New York yard for the construction of an additional battleship, of the Philadelphia yard for the construction of one battle cruiser and one battleship (later modified to two battle cruisers and to include two minesweepers), of the Norfolk yard for one battleship, of the Charleston yard for three additional destroyers, of the Puget Sound yard for the construction of two auxiliaries or one capital ship (later modified to include two minesweepers), and the expansion of existing ways at the Mare Island yard to accommodate the construction of one large battleship.

Development of plans.—Prior to and concurrently with the working up of this schedule, type plans were prepared in consultation with the bureaus concerned and under the general supervision of the Board on Development of Navy Yard Plans (referred to on p. 129, ante), to show the ideal general layout of a plant and also to show the general features required for each of various utilities such as the different shops, building ways, fitting-out berths, etc. Such requirements as maximum clearances and crane capacities required to handle various parts of ships assembled in shops; the maximum clearances required for ships, with staging, shores, etc., at ways, and weights necessary to be handled on ways; the weights to be handled in fitting out of ships; and arrangement of facilities in the manner most favorable to continuous routing of materials to and through shops and between shops and ways and fitting out pier were determined at this stage.

The criterion for the determination of the dimensions, clearances, and weights which was used in the preparation of the type plans was a hypothetical ship whose dimensions were fixed by the maximum capacity of the locks of the Panama Canal and of the world's largest dry docks. This ship would have a length of 1,000 feet, beam of 109 feet, and draft of nearly 45 feet; and inasmuch as the new facilities for capital-ship construction have been made adequate for the construction of such a ship, or capable of being readily extended therefor, it is anticipated that these facilities will serve, without radical change, for many years to come.

The thoroughness with which the preliminary interbureau work leading to the development and completion of these plans was done is evidenced by the fact that it has been necessary to make but few changes of any importance in the original plans.

In planning the improvements to be undertaken at the various yards the type plans thus prepared were used as far as was practicable, taking into consideration local conditions as to existing facilities, additional needs, space available, foundations, materials of construction, etc., and the limitations of funds. By thus following a uniform plan, considerable time was saved in the preparation of designs and details and in the fabrication and erection of a number of structures.

Upon approval of the schedule of improvements at the various yards, referred to above, it was necessary to prepare plans and specifications for the numerous projects and parts of projects in the shortest possible time. To design the individual structures and prepare these plans and specifications in greater or less detail, as required in each particular case, it was necessary to secure from each yard a large amount of data, such as test borings, test piles, elevations, contours, soundings, surveys of surface and subsurface structures, etc.

The technical force available for the shipbuilding facilities and development work had, for the most part, been only recently assembled and was by no means as large as the magnitude and urgency of the work would have warranted. Because of these conditions and the need of providing facilities for the actual construction of vessels at the earliest practicable date, it was necessary to make an especially careful study of the relative order in which the various projects would be needed, of the time required for the construction of each, and of probable interferences with construction, in order to place each project, or its component parts, under contract in the most logical order.

Difficulties.—The unprecedented magnitude of most of the projects contemplated and the many intricate engineering problems involved naturally added to the difficulty of preparing and completing plans and specifications for advertisement and of handling details after award of contract. The difficulties in construction, militating against early completion, were also formidable. On every hand the bureau was faced with the growing stringency in the material and labor markets, mounting costs, conflicting priorities of other Government work, and interferences with other contracts; in fact, every abnormal condition resulting from the declaration of war made itself felt in some degree and unavoidably resulted in more or less delay.

Results.—Although the improvements, in the main, were not completed until after the signing of the armistice, and although work on some individual projects is still under way (for example, the recon-

struction of battleship ways No. 1 at the navy yard, New York, and of the battleship ways at Mare Island, which projects could not be undertaken until after the launching of the *Tennessee* and the *California*, respectively, and several projects authorized by Congress to be undertaken in 1920 and 1921), the building capacity of the Navy's own yards has now been increased many fold, as well as placed on a most modern basis as regards plant for rapid and economical construction of vessels.

The following table is included in order to show the increase in capacity and the scope of the improvements effected: (Turn over.)

Increase in shipbuilding facilities, 1914–1920, showing scope of improvements.

Yard.	Building capacity, 1914.			Building capacity, 1920.			Principal facilities added			
	Number of ships	Class.	Approximate length	Number of ships.	Class.	Approximate length.	Number.	Description.	General dimensions.	Approximate cost.
			Feet			*Feet*			*Feet.* by *Feet.*	
Portsmouth	2	Submarines	250	6	Submarines	340	2		60 by 340	$150,000
									60 by 340	28,000
									85 by 250	226,000
									60 by 150	130,000
										230,000
Boston, Mass				1	Auxiliary	450	1	Building ways	70 by 450	165,000
								Extensions machine shop and foundry	200 by 280 40 by 250	900,000
								Miscellaneous		25,000
New York, N. Y	1	Battleship	600	2	Battleships	700	1	handling	130 by 700	1,670,000
							1	with bulkhead handling facilities.	130 by 700	1,750,000
							2	Machine shop extensions	120 by 220 120 by 260	412,000
							1	Light machine and electrical shop	6 stories 94 by 393	990,000
							1	Structural shop	232 by 580	1,420,000
										130,000
										200,000
										200,000
										250,000
Philadelphia				1	Auxiliary	500	1		100 by 500	175,000
				2	Battle cruisers	900	2		130 by 900	2,350,000
				2	Minesweepers	200	2		40 by 200	65,000
							1		150 by 325	630,000
							1		285 by 650	1,130,000
							1		105 by 230	400,000
							1		320 by 700	1,940,000
										250,000
							1		63 by 122	75,000
							1	e plant	64 by 64	42,000
							1		80 by 400	364,000
							1		100 by 1,000	834,000
							1		350 tons	875,000
							1		10 tons	50,000
							1		100 by 750	225,000
										450,000
								ng systems	100 by 270	3,000,000
										200,000

Norfolk, Va.				1	Destroyer	350	1	Building slip	80 by 430	180,000
				1	Battleship	700	1	....do	130 by 700	1,200,000
							1	Machine shop	160 by 600	890,000
							1	Foundry	295 by 410	900,000
							1	Pattern shop and storage	126 by 211	800,000
							1	Structural shop and steel storage shed	330 by 700 634 by 340	2,180,000
							1	Galvanizing plant	82 by 152	110,000
							1	plant	38 by 135	60,000
							1		100 by 1,000	2,100,000
							2		10 tons.	100,000
							1		150 tons.	360,000
								g systems	100 by 270	2,500,000
										450,000
								Miscellaneous		100,000
Charleston, S. C.				1	Destroyer	360	1	Building slip	50 by 360	
				3	....do	385	3	cranes.	40 by 385	165,000
							1		62 by 170	98,000
							1		25 by 320	25,000
							1		35 by 75	25,000
										150,000
Puget Sound, Wash.				1	Submarine	280	1		50 by 280	75,000
				2	Auxiliaries or	475	1		130 by 915	1,050,000
				1	Capital ship	915	1		55 by 440	50,000
				2	Minesweepers	200	1		146 by 122	132,000
							1			67,000
							1		20 tons.	50,000
										350,000
Mare Island, Calif.	1	Auxiliary	550	1	Battleship	700	1		130 by 700	200,000
				1	Destroyer	325	1		40 by 325	
				2	Destroyers	336	1		42 by 336	56,000
							2		100 by 190	500,000
							1		300 by 700	2,250,000
							1		38 by 115	45,000
							1			80,000
							1		150 tons	700,000
										100,000
										300,000

Storage development.—The expansion of shipbuilding facilities necessitated, of course, a corresponding increase in facilities for the storing of industrial materials, supplies, etc. These facilities are described in some detail elsewhere in this volume.

PROJECTS—CONSTRUCTION DETAILS.

INDUSTRIAL BUILDINGS.

General.—As has been noted before, the various industrial buildings were designed on the basis of the type layout worked up in consultation with the bureau concerned; dimensions and clearances were determined upon after consideration of operating and routine requirements, equipment to be installed, sizes of pieces to be handled, etc.

Crane capacities and lifts were determined upon after consideration of the dimensions and weights of material to be handled, and in so doing it was endeavored to provide equipment for handling, economically, the ordinary run of weights as well as the maximum weights expected. To allow of the greatest practicable degree of freedom in the assembling of parts in shops, and consequent economy in ship construction, the maximum crane capacities have been fixed on a liberal basis. In many instances the maximum capacity is obtained by the use of two cranes acting together; which method has the obvious advantage of providing the maximum capacity required (comparatively seldom needed) without the purchase of cranes too cumbersome to take care of the routine handling.

Other considerations invariably borne in mind in shop design were adequate natural lighting and ventilation, heating and electric lighting, and safety of workmen. The large proportion of sash in side walls and roofs will be noted from the illustrations. In general, the roofs of the large shop buildings were constructed with transverse or longitudinal monitors. Heating and ventilating and lighting systems were designed in accordance with the best modern practice, and plans for buildings and services were examined and checked from the standpoint of safety.

The materials generally used in the construction of shop buildings were: Framework, structural steel except for galvanizing and oxyacetylene plants, pattern shops, and other smaller shops; side walls, base course, 8-inch reinforced concrete or brick, remainder, steel sash and plastered 4-inch hollow terra-cotta tile; roofs, gypsum composition (or in some cases concrete or wood sheathing) covered with standard pitch (or asphalt), felt and slag, or asphalt and asbestos roofing; floors, wood plank, wood block, concrete, asphalt, or dirt, as required to suit the particular service for which areas are to be used.

Structural steel was dictated as the proper material to be used for the framework of most of the shop buildings by the long open aisles and long spans required, which conditions would make any other class of construction bulky, heavy, and uneconomical, if not entirely inadequate from a structural standpoint. In the multiple-story buildings with short spans, reinforced concrete was used as being the most economical.

Gypsum composition was quite generally used for roof slabs on account of its lightness and consequent economy in design of steelwork, and its excellent insulating qualities.

Hollow tile side walls were used for similar reasons. Steel sash was used for obtaining maximum daylighting, and because of its almost equally obvious advantages of economy, fire resistance, and rapidity of erection.

Structural shops.—The first of the modern structural shops to be constructed was that at the navy yard, Norfolk, Va., authorized in the naval appropriation act of August 29, 1916. This building is 300 feet in width and 700 feet in length, and is divided into three longitudinal aisles of 100 feet width each, serving as shape, plate, and smith and boiler shops, respectively. The shape and plate aisles have clear heights of 46 feet, and are each equipped with two overhead traveling bridge cranes of 15 tons capacity and 38 feet lift, and also with two tiers of traveling wall cranes of 3 to 5 tons capacity on each side. The smithery aisle has a clear height of 67 feet, and has 15-ton bridge cranes, and also wall-crane service similar to that of the other aisles. In addition, this aisle is provided with an 80-ton bridge crane, of 55 feet lift, above the 15-ton cranes. Although only one 80-ton crane has been provided thus far, the runway is designed for the use of two such cranes acting together to provide an ultimate lifting capacity of 160 tons.

This capacity is based on the weight of the largest forgings, such as main turbine motors, turbine casings, sternpost castings, boilers, etc.

An interesting feature of the bridge cranes of the smith shops is that they are arranged for complete electrical control from stations on the floor of the shop, from which level their operations can be more perfectly coordinated with those of the forging hammers and presses than is possible from the usual operator's cage located far above the level of the blocks.

Above the shape aisle is the mold loft, 100 feet by 700 feet, on the floor of which the lines of ships are laid out, and templates made for the work of the structural shop.

The type plan for a structural shop allows for lateral extension of the group to provide for sheet metal and pipe and plumbing shops,

and such future extensions have been borne in mind in the location and details of buildings of this character actually placed.

Another important feature of the Norfolk structural shop group is the steel-storage shed located at one end of the shops, in which the plain plates and shapes are stored on especially designed foundations, bearers, and racks, ready for routing into the fabricating shops. A feature of this shed is the crane service, four lines of cranes being provided to move the material to cars operating on tracks running at right angles to cranes and into the shops. Each crane is equipped with two trolleys for convenience in the handling of long plates and shapes.

At Philadelphia, the next yard at which a structural shop was constructed, the building was made to duplicate that at Norfolk, except that it was found satisfactory and economical to modify the design of the smithery by dividing its 100-foot aisle into a 65-foot aisle, with full height and crane facilities, and a 35-foot aisle of comparatively low height, and with only a 5-ton bridge crane. This saving was due to a decision to place the heating furnaces under the 35-foot aisles opening into the 65-foot aisle and to provide greater headroom and full crane service only at the operating side of the furnaces. The plan for Philadelphia contemplates the construction of a steel-storage shed similar to that at Norfolk at such time as noninterference with dry-dock construction and availability of funds will permit.

The next shop to be constructed was that at New York, but on account of the limited space available, the initial construction was limited to shape and plate aisles 100 by 580 feet and a mold loft 120 by 580 feet. The development plan, however, contemplates ultimate expansion to full size and to include all structural activities. On account of restriction of site, the steel-storage area at New York is located parallel and adjacent to the building ways, but material will be routed in the same manner as at other yards—raw material from steel storage to one end of shop, and through shop; fabricated material from opposite end of shop to erection space and building ways.

The Mare Island shop, which was specifically authorized in the naval act of July 1, 1918, and is now nearing completion, duplicates the Philadelphia shop in all important respects.

All of the above buildings were constructed under contract: the Norfolk building by Geo. E. Wyne, of Washington, D. C.; that at Philadelphia by P. F. Gormley, Washington, D. C.; at New York by Norcross Bros., of Worcester, Mass.; and at Mare Island by the American Bridge Co., of New York, and the Clinton Construction Co., of San Francisco, Calif. The steelwork (amounting to nearly

Structural shop, Navy Yard, Norfolk, Va.

Steel-storage shed, Navy Yard, Norfolk, Va.

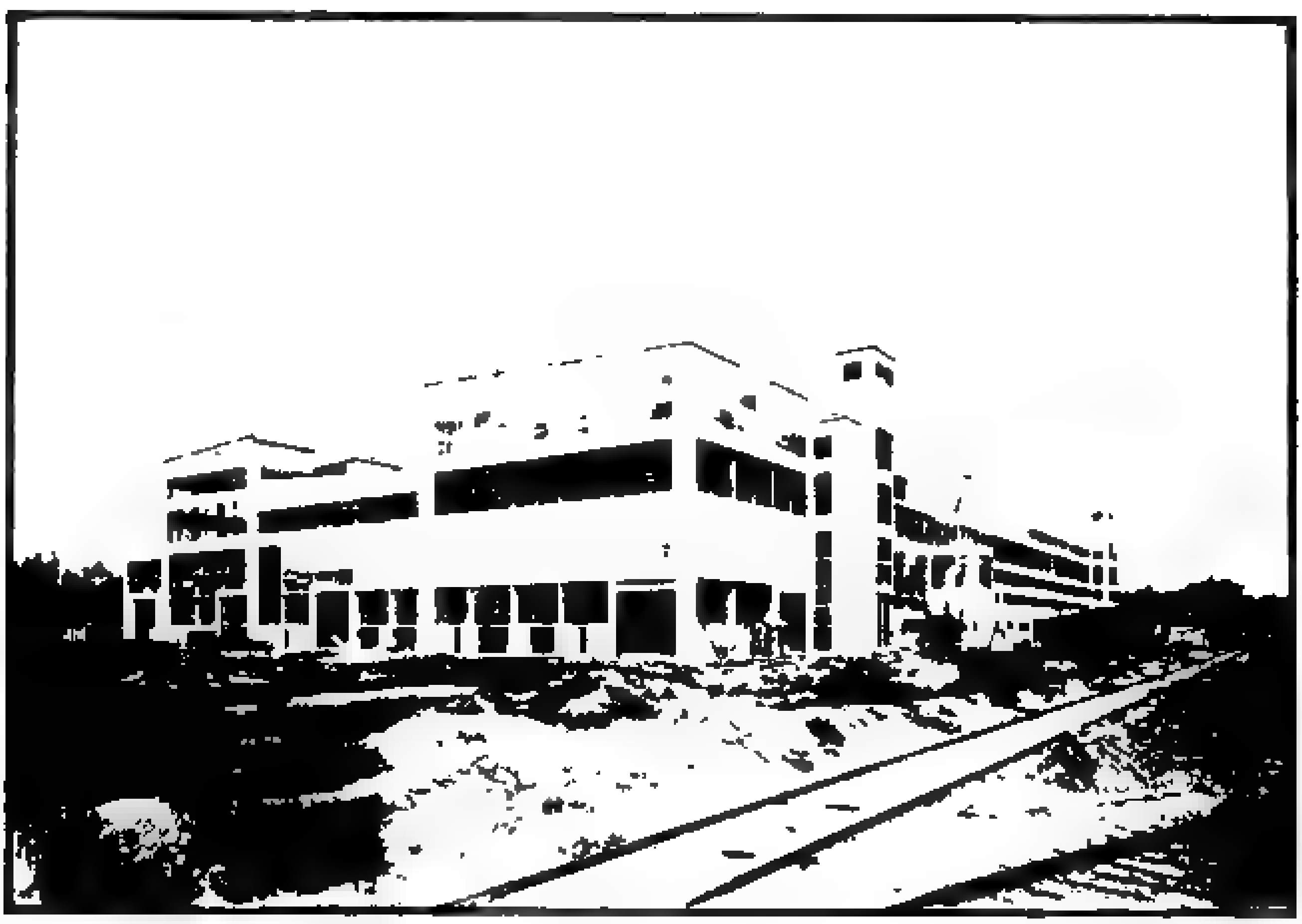
Structural shop, Navy Yard, New York, N. Y.

Structural shop, Navy Yard, New York, N. Y. Partial interior view.

Structural shop, Navy Yard, Philadelphia, Pa.

Interior of plate shop, Navy Yard, Philadelphia, Pa.

Mold loft in structural shop, Navy Yard, Philadelphia, Pa.



Structural shop, Navy Yard, Mare Island, Calif.

6,000 tons for each of these buildings except at New York) was fabricated for the Norfolk shop by the McClintic-Marshall Co., of Pittsburgh, Pa., and that for the other shops by the American Bridge Co.

Foundries.—The typical foundry building comprises a high center aisle, 80 feet wide; two lower side aisles, one of 55 feet width with a mezzanine floor, and one of 45 feet width; and a 100-foot material and flask yard adjacent to the latter.

The material yard is served by an overhead traveling crane of 10 tons capacity and 40 feet lift. The adjacent side aisle, into which materials are moved from the open yard, or from bins opening directly into the foundry, is of one story for the greater part of its length, 32 feet high to bottom chords of roof trusses. This aisle contains the cupolas and the various converters, furnaces, etc. At the cupolas a second floor is provided for charging, with an intermediate floor to house the blowers for the cupolas. The single-story portion of this side aisle is provided with 2-ton and 5-ton traveling cranes.

The center (main) aisle, in which the large castings are molded, poured, and handled, is 75 feet high to bottom of roof trusses, and is provided with three tiers of cranes—an 80-ton bridge crane of 63 feet lift, two 15-ton cranes of 50 feet lift, and two traveling wall cranes of 5 tons capacity on each side of the aisle. The 55-foot side aisle, with a gallery floor 22 feet above the main floor, houses molding machines, crucibles, cleaning and grinding apparatus, etc., and is served generally by monorail cranes of ½-ton capacity and by 2-ton traveling bridge cranes.

A foundry of this type, 408 feet in length, was constructed at the navy yard, Norfolk, and one 648 feet in length at the navy yard, Philadelphia. Both of these buildings are designed and located for extension to an ultimate length of 1,000 feet.

On the recommendation of yard officials a modified design for walls and roof was used at Philadelphia, with inclined side walls of steel sash and glass for the main bay, and continuous top-hung ventilating sash for the upper portion in lieu of the usual design (see illustration).

Both of these buildings were constructed under contract—the one at Norfolk by George E. Wyne, of Washington, D. C., and that at Philadelphia by Warren, Moore & Co., of Philadelphia.

At the navy yard, Boston, the foundry and machine-shop group (building 42) was remodeled and extended, the former copper, testing, and pipe shops and building 43 being demolished and replaced with modern construction. A further extension to the foundry, consisting of a lean-to building and a flask yard, is now nearing completion. The remodeling and extension work was done under con-

tract with the Evatt Construction Co., of Boston, and the lean-to and flask yard under contract with Coleman Bros., of Chelsea, Mass.

At the Portsmouth (N. H.) yard the existing foundry was extended.

Pattern shop and storage buildings.—The type pattern shop and storage building is of four stories, the lower three stories of reinforced-concrete flat-slab construction, used for storage of patterns, and the upper story of steel framework with adequate daylighting, ventilating, heating, etc., and light crane facilities for shop purposes.

Such a building, 126 feet wide and 211 feet long, designed and located for extension to about 550 feet in length, is being constructed adjacent to the new foundry at the Norfolk yard, and a similar one, 105 feet wide, 230 feet long, and three stories in height, designed and located for extension to 400 feet in length and increase in height to four stories, has been constructed adjacent to the new foundry at the Philadelphia yard. A smaller reinforced-concrete building of the same general type was constructed at the Charleston (S. C.) yard. These buildings are fireproof and modern in every respect, and are provided with electric elevators and handling equipment and steel racks for the storage of patterns.

The Philadelphia building was constructed by M. H. McCloskey, of Philadelphia, and the Charleston building by the navy yard public works force. The Norfolk building is being constructed by the Boyle-Robertson Construction Co., of Washington.

Machine shops.—The type plan for the machine-shop group contemplates, for heavy and medium machine shops, a mammoth building with two main (center) aisles for heavy machine and erection work, each 80 feet wide and 88 feet high to bottom chords of roof trusses, and each equipped with two 150-ton traveling bridge cranes of 70 feet lift and two 15-ton cranes of 68 feet lift; also two side aisles for lighter machine work, each 50 feet wide, equipped with 20-ton traveling bridge cranes of 26-foot lift for the main floor, and with a mezzanine floor provided with 5-ton cranes of 18-foot lift. The ultimate length contemplated is 1,000 feet. The necessary shop offices, tool rooms, toilets, wash rooms, substations, etc., are housed in lean-to structures.

The enormous lifting capacities for the main aisles of 150 tons for a single crane and 300 tons for the two together are based on the greatest loads expected to be handled, such as a modern turret for two 16-inch or three 14-inch guns, completely assembled, with its armor and turning mechanism, weighing altogether about 290 tons; a 16-inch 50-caliber gun weighing approximately 200 tons; a completely assembled boiler; a section of 14-inch side-armor plate of 64 tons; or a completed basket mast for a battleship.

Foundry, Navy Yard, Norfolk, Va.

Foundry, Navy Yard, Philadelphia, Pa.

Foundry Navy Yard, Philadelphia, Pa. Interior view

Foundry, Navy Yard, Boston, Mass. First extension.

Foundry, Navy Yard, Boston, Mass. Second extension.

Pattern shop and storage building, Navy Yard, Philadelphia, Pa.

Pattern shop, Navy Yard, Charleston, S. C.

The type machine-shop group provides also for a multiple-story light machine and electrical shop adjoining the structure just described.

Of the heavy machine shops actually constructed, those at Norfolk and Philadelphia most closely follow the type design. At Norfolk one-half the width of the type building, one 80-foot main aisle and one 50-foot side aisle, a 30-foot lean-to, and 600 feet of length have been constructed. This building is capable of being extended laterally to the full width of the type. The crane service is as described for the type building, except that only one 150-ton crane has been provided to date.

An interesting feature of this building is the end door of the main aisle, which was designed to permit the passage of the 150-ton cranes, with maximum load, in order to move heavy assemblages from the erecting floor direct to barges for immediate transfer to the fitting-out crane and installation aboard ship. This door is 88 feet high and 79 feet wide over all, but for structural reasons it is divided into three main parts, approximating, roughly, the silhouette of the crane with a maximum loading. These larger parts are further subdivided, and the whole system is arranged for motor operation with convenient control.

The Philadelphia machine shop forms a so-called "extension," 325 feet long, to the old machine shop. Their relative magnitude may be judged from the accompanying photograph. The new structure is of the same general cross section as the Norfolk shop. It is capable of being extended laterally to the full width of the type shop and to a length of 675 feet.

At the New York yard the main part of the old machine shop (building 128) was extended a distance of 235 feet. This extension was made along the lines of the existing structure, with the addition of a mezzanine floor in one of the side aisles. Building 128 was also extended by roofing over an adjacent courtyard.

At the New York yard a six-story light machine and electrical shop, 94 feet wide by 393 feet long, was also constructed, the materials being steel frame and brick.

At the Boston, Portsmouth, and Mare Island yards important extensions were made to existing machine shops. Of these, only the extension to machine shop No. 1 at Mare Island closely approximates the type construction described; the design of the other yards named, which were not otherwise equipped for the construction of capital ships, being such as to meet local conditions and requirements.

The provision of a large and modern machine shop for the naval station, Pearl Harbor, was taken up shortly after the armistice.

The machine shop buildings mentioned were all constructed under contract—the building at Norfolk by George E. Wyne, Washington,

D. C.; at Philadelphia by the McClintic-Marshall Construction Co., Pittsburgh, Pa.; at New York by Post & McCord, New York City; at Boston by the Evatt Construction Co., Boston; at Portsmouth by Levering & Garrigues, New York City; and at Mare Island by George Wagner, San Francisco.

Galvanizing plants.—The first of the modern galvanizing plants constructed for naval requirements was at the Philadelphia yard. This building is of one story, 62 by 122 feet in plan, and 53 feet high over all. It is equipped with a 6-ton traveling bridge crane of 25-foot lift running lengthwise of the shop, and with a 3-ton jib crane for handling material from cars and over one of the vats.

On account of the corrosive action of gases and acids present in a shop of this character, the entire building framework, including roof trusses of 62-foot span and excepting only crane runway girders, was designed and constructed of reinforced concrete.

A plant of the same type but somewhat larger—82 feet wide by 152 feet long and 62 feet high over all—was constructed at the Norfolk yard. As at Philadelphia, the wall framing is of reinforced concrete, but on account of the greater span, steel roof trusses coated with "gunite" (Portland cement mortar applied by compressed air) were used.

Oxygen-hydrogen-acetylene generating plants.—Because of the very extensive use of oxygen, hydrogen, and acetylene in cutting and welding in connection with ship construction and repair, it has been found desirable and economical for the principal yards to maintain their own plants for generating these gases.

Fireproof buildings of reinforced concrete, brick, and tile were constructed to house these activities at the Philadelphia, Norfolk, and Mare Island yards, and one is now under construction at the Charleston yard.

The Mare Island building, as a typical instance, is 38 feet wide and 135 long, one story high. For safety the various activities, such as oxygen and hydrogen generating, oxygen charging, hydrogen charging, acetylene generating, and acetylene charging are all separated by fire walls. The gases are stored in steel holders outside of the building.

Boat shop.—At the navy yard, Philadelphia, an addition to the boat shop, 80 by 400 feet, 46 feet high to underside of roof trusses, and equipped with two 15-ton traveling bridge cranes, was constructed.

Miscellaneous buildings.—At the larger yards it was also necessary to construct various auxiliary buildings, such as engine and locomotive-crane houses, toilet and locker buildings, etc.

Power plants.—To take care of the great expansion of industrial activities at the yards equipped for shipbuilding, extensions to power-

Machine shop, Navy Yard, Norfolk, Va.

Machine shop, Navy Yard, Norfolk, Va. Interior of main aisle.

Machine shop (center) and "extension" (left), Navy Yard, Philadelphia, Pa

Maine aisle of machine-shop extension, Navy Yard, Philadelphia, Pa

Light machine and electrical shop nearing completion, Navy Yard, New York, N. Y.

Interior of extension to heavy machine shop, Navy Yard, New York, N. Y.

plant buildings, and additions to power-plant equipment were necessary in nearly all cases.

At Philadelphia and at Norfolk, where entirely new industrial areas were created and existing power plants were too small and too restricted as to location to permit of expansion (as well as somewhat remote from the new center of load), it was considered necessary that new power plants be constructed. The buildings housing these two plants, which were constructed from the same plans and under the same contract, consist of a generator room 77 by 102 feet, 67 feet high to roof, pump room 35 by 114 feet, and a boiler room 84 by 157 feet, with a continuous overhead coal bunker of 2,600 tons capacity, 94 feet high from basement to roof. An outside coal storage and handling plant with conveyor system from storage to bunkers is provided at each yard. The outside coal storage capacity is 18,000 tons.

Further discussion and description of these plants will be found in another chapter.

The power-distributing lines for industrial developments, carried in a system of tunnels and trenches, are also reserved for separate treatment.

The buildings were constructed under contract with the M. J. Roche Construction Co., of Cincinnati, Ohio; the Philadelphia coal-handling plant by the Guarantee Construction Co., of New York City; and the Norfolk coaling plant by R. H. Beaumont & Co., of Philadelphia, Pa.

Gun shop, Naval Gun Factory, Washington, D. C.—This project unusually interesting from an engineering standpoint, was handled in connection with the shop design described in this chapter. The building, which has cranes of extraordinary capacity and lift (300 gross tons; 40 and 100 foot lifts) and a shrinkage pit 100 feet deep, is described elsewhere in connection with the bureau's naval-ordnance projects.

SHIPBUILDING SLIPS.

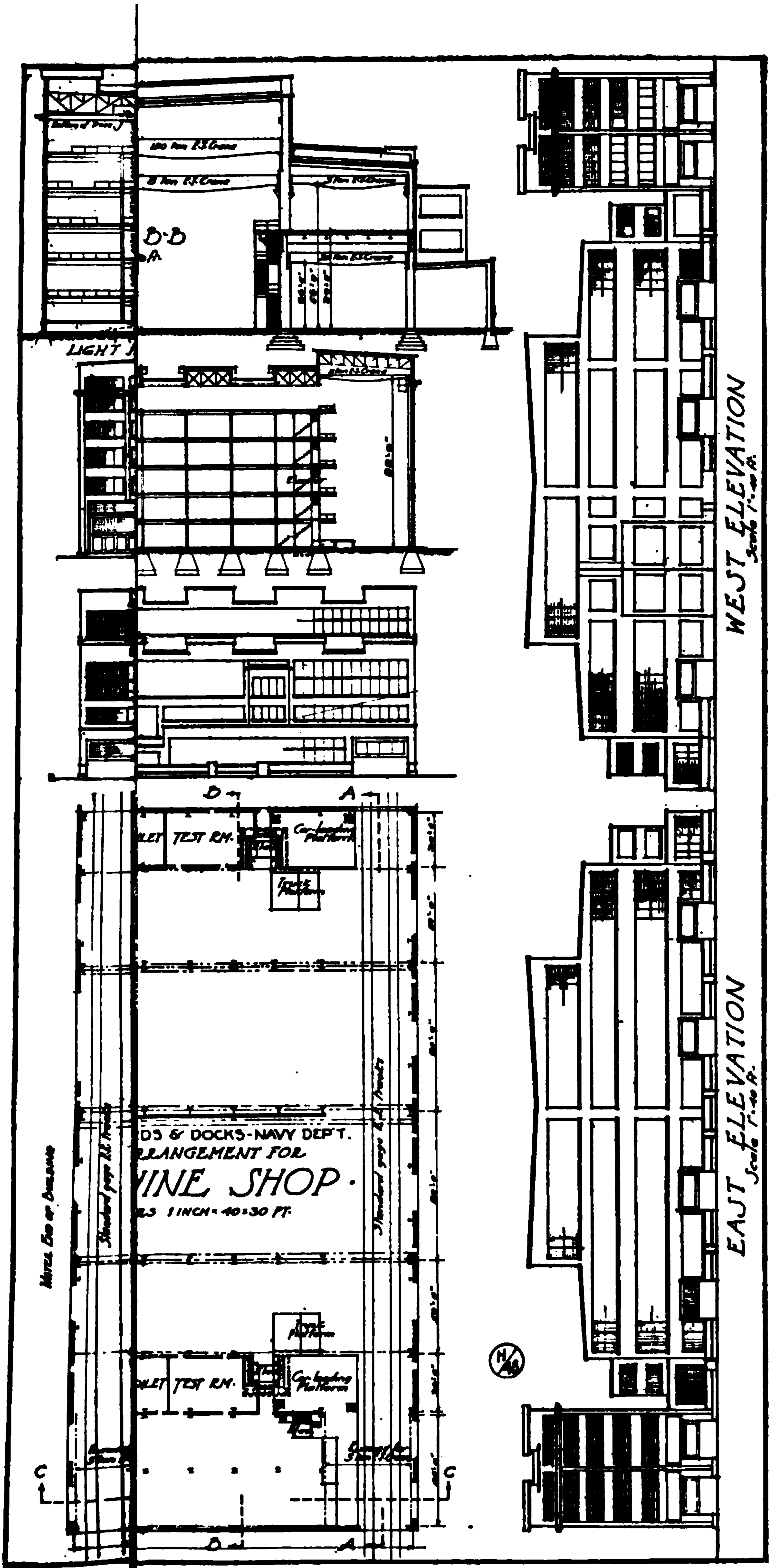
General.—The new shipbuilding slips, by which term is designated the whole waterfront structure and forebay devoted to the construction and launching of a vessel, were designed in accordance with the requirements of the Bureau of Construction and Repair and of the shipbuilding yards as to principal dimensions and clearances, launching weights, weights to be handled by cranes, etc., and in accordance with the specific requirements of the locality as to foundation conditions, space available, range of tides, and the like. The assumptions for the ultimate capacity of the plants for the construction of capital ships have been mentioned heretofore. The building slips were, of course, designed with these assumptions

Power plant, Navy Yard, Philadelphia, Pa. View showing coal-handling plant (left), taken from crane runway of shipbuilding slip.

Generator-room end of power plant, Navy Yard, Philadelphia, Pa.

Coal handling installation at power plant, Navy Yard, Philadelphia, Pa.

Overhead coal bunkers in power plant, Navy Yard, Philadelphia, Pa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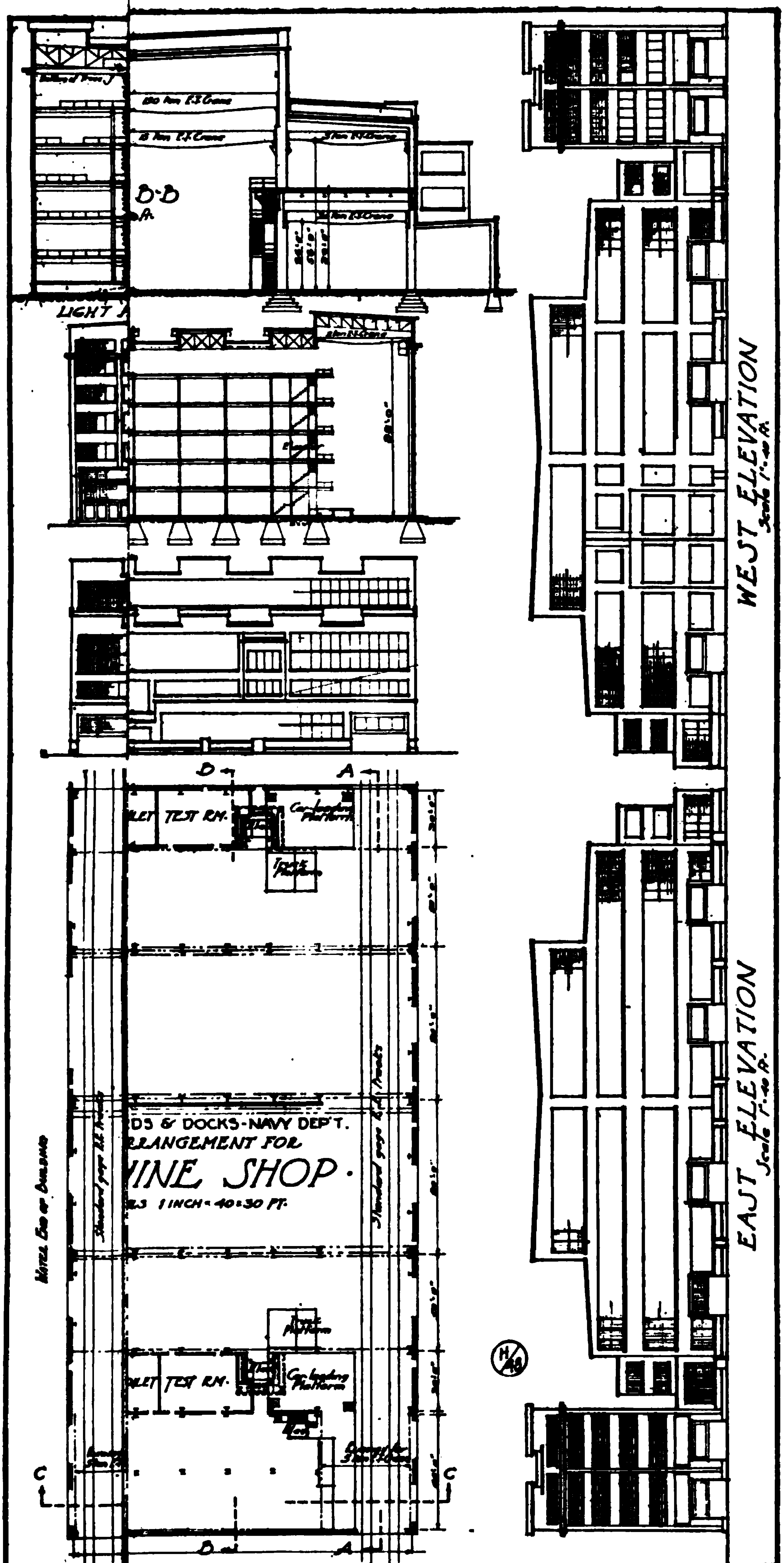
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in mind, although the initial construction in each case is for the type of ship immediately assigned to the yard; thus slips at yards where battleships have been assigned have been constructed for vessels of a length of 700 feet, and at yards where battle cruisers have been or may be assigned, for ships of a length of 900 feet; but all ways for capital ships are capable of being extended for ships up to 1,000 feet in length. The general plans illustrating this chapter show typical designs for shipbuilding slips and indicate the general arrangement, construction, dimensions, and loads.

Launching ways.—The typical layout for shipbuilding slips for capital ships provides for launching ways (by which is meant the floor or platform on which a ship is built up and launched) of the usual "declivity" type capable of carrying enormous loads under the keel blocks and groundways and served by electrically operated traveling bridge cranes operating above the ways on high steel structures. A lower crane runway structure is provided at the inboard end of the slips to serve the area in which bulkheads, frames, etc., are assembled before being placed in the hull.

The construction of the launching ways proper varied at the different yards at which slips were constructed on account of foundation conditions, type of ship to be constructed, desires of the yard, and expediency, but crane runways and cranes were constructed according to uniform plans.

Crane runways and overhead cranes.—The clearance between the towers supporting the crane runways is in each case made 130 feet to allow for the construction of a ship of maximum beam, with the necessary staging, working platforms, and supports for shores. A standard-gauge railroad track serving the slip is located under the portals of the outer towers, and two tracks are placed under the towers between slips. The legs of these towers toward the slips slope outward, so that the inside width is increased from 130 feet at tops of portals to 150 feet at the crane-runway level. This allows the cranes to plumb the railroad tracks under the towers as well as the entire width of the slip.

The cranes operate in two tiers—a lower tier of two cranes of 40 tons capacity, 151-foot span, and about 135-foot lift above mean low water; and an upper tier of four cranes of 10 tons capacity and about 155-foot lift. These upper cranes operate on two longitudinal runways of about half the width of the slip, the rails at the center of the slip being supported on a structure suspended from the transverse trusses which connect and brace the towers. In order that the 10-ton crane service may cover the entire width of the slip without a gap at and on each side of the center supports, the two cranes on one runway are of the "underslung" type; that is, the crane trolley operates on the bottom chord of the crane girders, which extend

under the supporting structure far enough to allow the trolley travel to overlap that of the cranes on the other half of the slip.

The design of the runways is of unusual engineering interest, because of the magnitude of the structures, the multiplicity of forces due to cranes and wind, and the statical indeterminacy of stresses in the component parts of the structure. The original detail design was prepared by the American Bridge Co., of New York, on the basis of the bureau's outline drawings and specifications, and was checked in detail by the bureau. The single runway for the single battleship slip at Norfolk contains 4,045 tons of structural steel; the double structure, with bulkhead handling runways for two battleships, at New York, 7,467 tons; and the double structure for two battle cruisers, at Philadelphia, 9,948 tons.

Five of these crane runway structures have been constructed from the same plans, the two at Philadelphia by the American Bridge Co. and the one at Norfolk and two at New York by the McClintic Marshall Construction Co. The 40 and 10 ton cranes for all of these ways were constructed by the Niles-Bement-Pond Co., of Philadelphia.

Philadelphia ways.—The first designs for the two building ways at Philadelphia contemplated a reinforced-concrete deck structure inboard of the intersection of grade and mean low water, supported on timber piles cut off at the permanent ground-water level. The permanently wet outboard portion of the ways was to have been of timber, as in the design finally adopted. Bids were taken on this concrete-deck design, but the cost was found to be excessive in view of the work it was necessary to accomplish with the funds available. Because of the greater expense and time required for permanent concrete construction, and on the assumption that the more or less temporary construction above the wet line could be permanently replaced after a number of ships had been launched, the department made the decision to install all-timber construction.

The type of construction varies somewhat with the load, but consists in general of close transverse pile bents, well braced in both transverse and longitudinal directions, capped with heavy oak and yellow-pine timbers, and decked over with heavy yellow-pine planking. The piles are, of course, densely spaced under keel and groundway supports and much more sparsely spaced in outer areas, where only the lighter loads of staging, working platforms, and shores are supported. The ground-way supports from the pivoting point outboard are carried on piles spaced 2 feet center to center both ways. Passageways for men and materials are provided under the ways to save time ordinarily consumed in going around the head of the slip. Space has been conserved by installing such necessary facilities as

Shipbuilding slips Nos. 2 and 3, Navy Yard, Philadelphia, Pa. Outboard view.

Shipbuilding slips Nos. 2 and 3, Navy Yard, Philadelphia, Pa. Inboard view.

Battleship building slip, Navy Yard, Norfolk, Va.

Launching of destroyers from battleship building slip, Navy Yard, Norfolk, Va.

offices, tool rooms, rivet and bolt reclamation, and storage under the high part of the ways at the inboard end.

The outboard end of the ways, consisting of pile bents supporting ground ways, were designed for installation either under water (by diver) or behind a cofferdam, the contractor electing (as did the contractors for the New York and Norfolk ways) the latter method.

The ways proper at Philadelphia were constructed in the main under contract with the Foundation Co., of New York, and the passageways, offices, tool rooms, etc., under contract with McCloskey & Bahls, Philadelphia, Pa.

Norfolk ways.—At the Norfolk yard, where a slip for one battleship was built, timber construction of the same type as at Philadelphia was used, except that the platform was not constructed to the full width and length of the slip, and passageways and offices, etc., under the ways were not included.

During the war urgently needed destroyers were constructed (in parallel) upon these ways.

These building ways were constructed under contract with the George Leary Construction Co., of New York.

New York ways.—Two building slips for battleships have been constructed at the New York yard. Slip No. 2 was constructed immediately west of the old battleship slip, beginning late in 1917, and the latter, No. 1, was entirely reconstructed, practically as a duplicate of No. 2, to permit the building of larger ships. The construction of the former was delayed by the difficulty in clearing the site of existing yard activities, and reconstruction of the latter could not begin until after the launching of the *Tennessee* on April 30, 1919.

The designs for the New York ways, prepared at the yard and checked by the bureau, provided for construction somewhat similar to that originally planned for Philadelphia—a reinforced-concrete deck founded on timber piles cut off at water level—except that the concrete deck is made only of sufficient width to carry keel blocking and ground ways, and that the deck is constructed in steps conforming to a slope of one-half inch per foot instead of a continuous slope. The ground ways, of timber, are built up on these steps to a uniform slope of eleven-sixteenths inch per foot. The construction for the inboard 312 feet of the ways comprises a deck of reinforced-concrete slab and longitudinal girders, supported on transverse concrete piers 12 feet on centers resting on timber piles cut off underground. For this distance (312 feet) some economy is effected by omitting the deck-and-pier construction for 4 feet on each side of the keel supports, leaving a keel support 8 feet wide and two ground-way supports, each 14 feet wide. The remaining 312 feet of concrete con-

struction consists of heavy reinforced slabs or mats, 44 feet wide, resting directly on the timber piles. The last 131.65-foot length of the ground ways, outboard (below mean low water), conforms to the ground-way slope of eleven-sixteenths inch per foot and is entirely of timber. The outboard ground ways are supported directly on the caps of transverse pile bents 2½ feet on centers. This part of the structure is supported laterally by bracing, ties between its two parts, spur logs extending to the sides of the slip, and by a fill of from 3 to 8 feet of broken stone.

The loads to be considered, due to dead-weight of a ship on the ways and the launching pressures due to pivoting, are enormous; the keel supports in the case described being designed for a live load of 20 tons per linear foot and the ground-way supports for 20 tons each per foot for the inboard end and for 30 tons per foot outboard of the pivoting point.

Timber adjustable staging supports, shores, and working platforms are also provided, supported on pile foundations between the ground ways and sides of slips.

The ways for slip No. 2 were constructed under contract with the Jarrett Chambers Co., of New York City, and those for slip No. 2 are now being completed by the Phœnix Construction Co., of New York City.

Puget Sound shipbuilding dry dock.—The most striking departure from customary practice to be found in the bureau's entire program of shipbuilding facilities was the construction of a shallow dry dock at Puget Sound in lieu of the usual building ways. A résumé of this operation is presented herewith from the personal account of the officer[1] at that time in charge of public works at the yard:

In the latter part of 1916 much time was given to the discussion of the types of building ways. Naturally attention was first given to the construction of inclined building ways, as this was the type generally used throughout the world for ship construction. During this discussion one of the draftsmen[2] of the public works department suggested the building of a shallow dry dock and presented a sketch which he had made for this purpose. The writer immediately recognized the merit of such a proposition and directed that plans be prepared in order to determine what difficulties might be encountered in putting the project through, together with approximate estimates as to cost to see if such a construction would be warranted.

There was nothing new in the idea itself. In Colson's Notes on Docks and Dock Construction the opening sentence states that "the term 'dock' was formerly applied exclusively to the slips or inclosures made for the purpose of building or repairing ships." Germany had built twin docks of a shallow design for shipbuilding purposes, and France and England had both built small structures of the same type. The writer also recalls that in conversation with the late Civil Engineer Cunningham, United States Navy, in years gone by

[1] Capt. (then Commander) L. E. Gregory (C. E. C.), United States Navy.
[2] Mr. Victor E. Hulteen.

Double shipbuilding slips, Navy Yard, New York, N. Y.

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Shipbuilding dock, Navy Yard, Puget Sound, Wash., showing caisson.

Shipbuilding dock, Navy Yard, Puget Sound, Wash. General view showing U. S. S. *Pyro* under construction.

we discussed such a proposition, although the same had never been attempted by our Government.

Plans were shortly thereafter developed to such an extent that it was found highly desirable to place the subject before superior authorities. It was proposed to build a dock of about 30 feet in depth over all, 130 feet in width, and 950 feet in length, serving the same with traveling revolving hammer-head cranes, and the following advantages were the principal ones noted:

(*a*) That the cost of such a dock at Bremerton, with four traveling cranes, would be no more than that of the inclined ways with a sufficient number of fixed hammer-head cranes or an overhead crane.

(*b*) Accessibility for workmen and materials of construction would be vastly superior because of the fact that the center of gravity of work installed would be below the yard level.

(*c*) Difficulties in launching would be negligible, and the cost of launching a large ship would also be negligible.

(*d*) Greater flexibility in time of launching would be secured, as work could be prosecuted to the fullest extent permissible with draft conditions. Fullest advantage could therefore be taken of facilities for equipment before the ship left her original position. This also would permit construction simultaneously of as many ships as the dock would hold and launching them at different degrees of completion.

It was also noted that the Bremerton yard was particularly adapted to such a construction, for at the depth at which this dock would be founded pile foundations would be unnecessary, and that piles would be required only for the support of the outer crane rail for this dock.

The entire idea, after having been discussed with yard officials, was placed informally before the Commission on Navy Yards, and this commission approved of the idea and suggested that it be followed up through official channels. It was therefore forwarded for the action of the Bureau of Yards and Docks. It is interesting to note that a day or so after the submission of this proposition to the bureau a personal note from the Assistant Chief of the Bureau of Yards and Docks was received stating that in making studies at the bureau some consideration had beeen given to the question of building a shallow dock for shipbuilding purposes, but that due to conditions not being well understood in Washington the idea had been abandoned.

In view of the decision to develop the yard for shipbuilding purposes, the writer was ordered to report at the bureau in Washington for duty in connection with yard development, and reported there on March 12, 1917. Discussions were immediately opened up upon this subject and an important conference was arranged in the office of the chief constructor. Lack of enthusiasm for this project was notable, particularly by the officers of the Construction Corps, principally for the reason that a shallow dry dock was a "handy tool" and was not sufficiently distinctive either as a dry dock or a building ways to warrant construction, particularly as it was considered a doubtful experiment; nor was the Bureau of Yards and Docks at that time anxious to press for the construction of this dock against the wishes of the Bureau of Construction and Repair. After discussions of pros and cons, the matter appeared to be one which was settled finally upon the cost of launching a capital ship. A question was asked as to the cost of launching the U. S. S. *Arizona*, the largest battleship launched to that date, and it is the writer's impression that this cost was stated to be approximately $50,000. When it was asked what it would cost to launch such a ship from a shipbuilding dock, it was stated that it would be merely nominal.

Apparently, consideration of the plan received increasing favor, for upon the 22d of March, 1917, the Chief of the Bureau of Yards and Docks decided to approve the construction of the shipbuilding dock. Two days later a letter was sent to the navy yard allotting to it the sum of $2,000,000 for equipping the yard for shipbuilding, the principal features of which were the approval of the idea of building this dock and equipping it with four traveling revolving hammer-head cranes. Accordingly, while the writer was still at the bureau, detailed plans were begun preparatory to placing this dock and its cranes under contract. The plans were drawn up under bureau supervision, and careful computations were made for steel reinforcement and stability of the dock as well as for the details of the caisson. During the greater part of the preparation of these plans the writer was present for conferences on all these details.

Bids were called for on the work, and were opened at the bureau on June 25, 1917. The award was made to the Sound Construction & Engineering Co., of Seattle, on June 30, 1917, upon a unit-price basis, the estimated total cost based on original estimated quantities being $566,000. The caisson was to be built by the manufacturing department of the navy yard. The traveling cranes were to be furnished by contract, and they were subsequently let to the McMyler Interstate Co., and were of a type not hitherto essayed with such a capacity.

A technical description of the dock construction is not proper at this place, but brief mention should be made of the general features of construction. It was desired that an ammunition ship ordered to be built at the navy yard be prosecuted without delay, inasmuch as war had been declared by the United States on Germany on April 6. It was decided, therefore, to press for the construction of the floor of the dock, together with a short section of the side walls, permitting the installation of the traveling cranes, in order that a part of the dock sufficient in which to begin the construction of the ammunition ship should be available at the earliest possible date. It was, of course, necessary with such a project that the caisson of the dock be built within the cofferdam, in order that it should be in place when the cofferdam was removed, all of which required unusual and interesting construction. The work was prosecuted by the contractor along the line indicated, and the caisson was built by the yard force immediately above the sill in which it was to be placed, on blocking 8 feet above the dock floor. It was lowered by sand jacks for which no precedents could be found, the details of the same being worked out by the public works department in the navy yard under the writer's direction. The civil engineer officer who was in direct charge of this work, Lieut. G. W. Plaisted, subsequently wrote an article upon it, which appeared in the Engineering News-Record of November 13–20, 1919.

During the construction of the dock but few hazards of nature were encountered, and these were readily met by careful work. One feature as to personnel is of interest in this connection. It was found that the work was not proceeding on the dock structure in a satisfactory manner, and it became desirable to remove the superintendent and secure another who could produce better results. It became necessary also to accelerate the enthusiasm of the contractor's men on this job, particularly the foremen in charge of gangs of workers. Therefore at the time of changing superintendents in favor of one who was personally known to the public works officer as being most efficient, and for the purpose of securing hearty cooperation and loyalty to him on the part of the various foremen under his direction, a modest banquet was given at a small café in Bremerton on July 16, 1918, at which the public works officer told the story of the inception of the dock and its importance to the station, for the benefit of those present; and it was a matter of great satisfaction to note

that from that time until the completion of the work the construction of this dock never lagged. It was completed January 10, 1919. It is proper to give considerable credit to Chief Inspector H. A. Sylvester, B. E., whose resourcefulness during times of emergency was of considerable benefit in pushing the work to a successful completion.

Some time after the Navy Department had authorized the construction of the ammunition ship it authorized the construction of a second one from the same plans, and the two ships were built in the dock, one forward of the other, and launched at the same time. The first one was completed to a degree far in advance of that at which ships are usually launched, whereas the second one was considerably behind in percentage of completion.

The two ammunition ships were ready for launching in the latter part of 1919, and the ceremonies of christening these ships were preceded by the exercises of dedicating the dry dock itself. This was done by Mrs. Gregory, who was the first one to operate the valve admitting water into this dock. The sponsors of the two ships launched immediately thereafter were Mrs. Bisset, wife of Commander Guy A. Bisset (C. C.), United States Navy, and Mrs. Suzzallo, wife of Dr. Henry Suzzallo, president of the University of Washington.

While it is too early for cost records to indicate a great economy in shipbuilding work effected by reason of building in a dock of this character, it was nevertheless most convincing to all those who have had to do with the shipbuilding operation that construction methods are simplified and made more economical thereby. It stands to reason that, from the standpoint of handling materials alone, with the center of gravity of the ship under construction below the yard level, there must be a saving in costs in placing weights on the vessel under construction. Furthermore, building on a level keel reduces the necessity for the use of batters in building bulkheads; and the greater accessibility afforded the yard working force is another feature which greatly affects the cost of work. Launching is deprived of its hazards, whereas this operation at some yards, where the channel is narrow, is extremely serious and expensive. It is the writer's belief that as time passes and further experience is gained from observation of construction in this dock the idea will be held in greater favor.

The shipbuilding dock as designed and constructed is 130 feet wide (clear, between copings) and about 928 feet long (clear, between coping at head and caisson gate entrance). Its floor is at elevation plus 96.5 and copings at elevation plus 127, while mean low water is plus 109.4, mean high water at plus 120, and extreme high water at plus 124.8.

The walls of the dock are of reinforced-concrete slab and counterfort construction. The floor is of plain concrete with broken-stone cross drains and stone-filled openings through the floor for relief of hydrostatic pressure on the bottom of dock. A system of longitudinal and lateral culverts drains the dock (of seepage water as well as in emptying) through a pump well and two 10-inch centrifugal pumps. The dock is filled by means of two sluice gates and culverts, one located on each side of the entrance, and through valves in the caisson.

The entrance gate is of the floating caisson type generally used for dry docks. The hull is constructed entirely of structural steel, with

Double slip for destroyer construction, Navy Yard, Mare Island, Calif.

Submarine-building slips, Navy Yard, Portsmouth, N. H.

creosoted white-oak fenders and wales and white-oak and white-pine sills bearing against the gate seats. The caisson is equipped with two 10-inch motor-operated pumps for emptying and two motor-operated capstans.

The crane facilities have thus far been provided on the basis of auxiliary vessels being constructed; and though they are in excess of those at the old New York and Mare Island ways, they do not provide the lifting capacity needed for the most efficient and expeditious construction of capital ships. These facilities consist, as above noted, of four traveling, revolving-jib (hammer-head) cranes of 20-ton capacity at 60 feet radius and 15 tons at 85 feet, with a 105-foot lift above the bottom, two operating on each side of the dock.

Of the two ammunition ships launched in December, 1919 (see above), it is of interest to note that the keel of one (the *Pyro*) was laid in August, 1918, well ahead of the armistice. Construction on the other (the *Nitro*) began in March, 1919.

Mare Island ways.—At the navy yard, Mare Island, Calif., extensive reconstruction of battleship ways No. 1, begun after the launching of the *California* in November, 1919, is still under way. There alterations consist principally of widening the slip on one side, lengthening ways at both ends, and strengthening foundations for heavier loading. No increases in weight-handling equipment have been made. The approved development plan for Mare Island provided for entirely new building slips of the type constructed at eastern yards, to be located near the new structural shop, and decision as to more extensive remodeling of ways No. 1 would depend upon the policy as to construction of the new slips.

Portsmouth, N. H., submarine ways.—At the navy yard, Portsmouth, N. H., two additional covered building ways were provided for the simultaneous construction of four additional submarines. The old ways in the Franklin ship house are now being extended, and crane facilities are being provided so that larger submarines can be constructed (the latter work undertaken since the armistice).

Destroyer ways, Charleston and Mare Island.—For destroyers, three building ways, located adjacent to the older ways, with additional hammer-head crane equipment, were provided at the Charleston, S. C., yard, and a double building slip for destroyers was provided at the Mare Island yard.

Minesweeper ways, Philadelphia and Puget Sound.—For minesweepers, double ways, with locomotive-crane service, were installed at the Philadelphia and Puget Sound yards.

FITTING-OUT PIERS AND CRANES.

General.—The type fitting-out pier is 100 feet wide, 1,000 feet long, and is designed for a depth of water of 40 feet. For convenience in

transporting, handling, and storing material under all conditions, four standard-gauge tracks are provided. The weight-handling facilities consist of a hammer-head crane of 350 gross tons capacity, located 400 feet from the outer end of the pier, and of two traveling hammer-head cranes of 5 to 10 tons capacity operating over the full length of the pier and located one on either side of the large crane.

Two of these piers were constructed—one each at the Philadelphia and Norfolk yards. Plans were prepared for the lengthening and remodeling of Pier C at the New York yard along similar lines, but, on account of interference with existing yard buildings and facilities, this project has been kept in abeyance pending the extension of the yard.

The Philadelphia and Norfolk piers, while identical as to principal dimensions, vary greatly as to type of construction, because of differing local conditions; the ravages of marine borers at Norfolk being one factor that had to be taken into account. Permanency was, of course, an essential requirement in either case, but the problem at Philadelphia was much the simpler on account of the absence of teredo, a fact which permitted the use of unprotected timber piling.

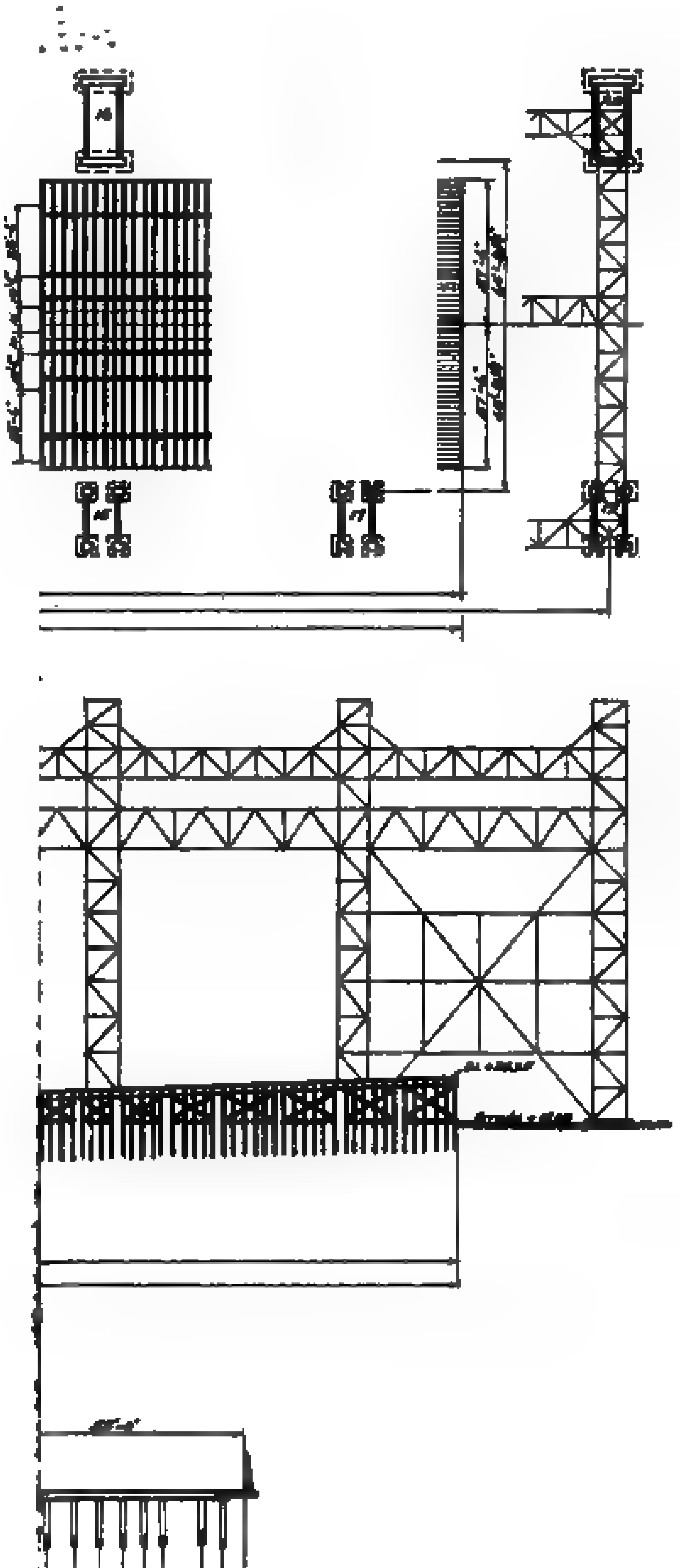
Philadelphia fitting-out pier.—The Philadelphia pier was constructed in from 25 to 35 feet of water, and is of the open type. The deck consists of a reinforced concrete slab and longitudinal beams supported on reinforced concrete cross walls spaced 10 feet center to center. The latter are, in turn, supported on plain timber pile bents framed at the top with timber clamps. The piles are driven into the hard gravel stratum underlying the river bottom, and are cut off a foot above mean low water.

The pier, including foundations for the large crane, was constructed under contract with the Snare & Triest Co., of New York City.

Norfolk fitting-out pier.—The Norfolk pier is of the closed, relieving-platform type (a timber platform, located just above mean low water, supported on timber pile and cap bents, surmounted by an 8-foot earth fill and with the earth below the platform retained by reinforced-concrete sheet piling at faces of pier, and above the platform by concrete retaining walls). This type was the natural choice in view of the conditions obtaining.

The pier was built on ground lying, in general, just above high water, so that the entire construction could be performed "in the dry" and without excessive excavation. After the successful conclusion of structural operations, the placing of railroad and crane tracks, cranes, trolley, conduits, etc., capstans and various fittings, and dredging of slips completed the pier for operation.

Both timber and concrete sheet piles are driven well into the marly clay underlying the site. The concrete sheet piles are of the



BUREAU OF YARDS & DOCKS-NAVY DEPT.

GENERAL PLANS

IIPBUILDING WAYS Nº 2

NAVY YARD, PHILADELPHIA PA.

SCALE

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tongue-and-groove type, 24 inches thick, 18 inches wide on the face, and 60 feet long, with bottoms beveled to facilitate driving of piles in close contact, so as to form practically a solid wall of concrete 24 inches thick around the entire structure.

The retaining walls are of hollow construction, an interior tunnel being provided for carrying pipes, ducts, etc., for the various services, such as air, water, electricity, and telephone required for pier and ships.

This pier, including foundations for the fitting-out cranes and also considerable adjacent bulkhead and quay-wall work of the same type, was constructed under contract with H. P. Converse & Co., of Boston, Mass.

350-ton fitting-out crane.—Only one of the proposed large fitting-out cranes has been constructed thus far, namely, the one at the Philadelphia yard, which has been completed since 1919. This crane has a single-load capacity of 350 gross tons.

General conditions.—The crane is located on the recently constructed 1,000-foot fitting-out pier at the yard, and its completion represents a definite step in engineering progress.

An idea of its size may be had from the fact that a 10-story building could be placed under the jib of the crane, and that its over-all height is over 245 feet, or about that of a 17 or 18 story building.

The cost of the entire crane structure above the foundations was approximately $875,000 and of the foundations $120,000, and it will serve the purpose of placing the heavier parts, such as the turrets, ordnance, armor plate, boilers, machinery, etc., on the capital ships to be constructed at the yard, as well as that of removing and placing heavy parts in connection with repairs to ships.

Tests of the new crane, in the course of which it was loaded to 125 per cent of rated capacity and operated in all cycles of duty, were successfully carried out. The largest single load in these tests was 980,000 pounds.

In the most spectacular of the tests the giant crane lifted a total load of 1,010,000 pounds—a locomotive weighing 100,000 pounds on the auxiliary (50-ton) hoist, a load of steel billets weighing 416,000 pounds on each of the main (175-gross ton) hoists, and a locomotive weighing 78,000 pounds on the machinery-house crane.

The maximum capacities, 50 gross tons for the auxiliary hoist and 350 gross tons for the main hoist, were determined in conjunction with the Bureaus of Construction and Repair and Steam Engineering as ones that would permit turrets, guns, etc., to be completely assembled (except for armor plating) in shops and transferred to the crane on barges or cars and placed aboard the ship intact, eliminating the operations of dismantling and subsequent re-assembling on board ship usually necessary, with a consequent marked increase in economy of time and money in the construction of capital ships. The large weight-handling capacity will also make the crane of inestimable value in the performance of major repairs to vessels.

The location of the crane at the waists of the ships berthed on either side of the pier will permit the placing of most of the heavy weights without moving or turning the ships. The placing of minor parts, which will form the greater proportion of the work of fitting out a ship, will be rapidly and economically done by two auxiliary small-capacity (5 to 10 tons) quick-acting traveling

cranes installed to operate along the pier on each side of the main crane. In some cases it is contemplated that these cranes may also be supplemented by floating derricks where it is desirable to expedite the construction by placing medium weights beyond the reach of the pier cranes without moving the ship.

General description of crane.—The crane, as designed and constructed, consists of a fixed portal 56 feet square, supporting, on deep girders, an octagonal tower about 56 feet wide at the bottom and tapering to a bearing pintle 5 feet in diameter at a height of approximately 201 feet above the deck of the pier. Supported vertically on this bearing pintle and revolving thereon is a horizontal cantilever jib or boom 300 feet long over all, to which is rigidly attached a "petticoat" which envelopes the fixed tower from the bottom of the jib down to a height just above the portal. The entire vertical load from the jib is transmitted to the tower at the pintle, mentioned above, but lateral thrusts are taken into the base of the octagonal tower by the circular girder which forms the rim of the 'petticoat," as well as at the pintle. The forward cantilever of the jib contains the three runways for the trolleys that carry the loads. The rear cantilever of the jib carries the counterweight and the house containing the machinery and drums for hoisting and lowering loads and racking the trolleys in and out on the forward cantilever. The machinery for revolving the jib is located at the level of the top of the portal girder, and the rotating impulse is transmitted through the rim of the "petticoat." This enveloping "petticoat" provided a greater factor of safety against failure by overturning of the jib, in the event of excessive accidental overload of crane, than would be given by the other and more usual design under consideration by the bureau, in which the jib is simply supported by the tower on a circular bearing similar to that of a swing bridge or a turntable. The entire framework of the crane is of structural steel of bridge grade, and the entire operation is by means of electricity.

Access to the jib, machinery house, etc., is provided by means of a steel stairway in the tower and an electrical elevator mounted on the outside of the "petticoat" and the jib.

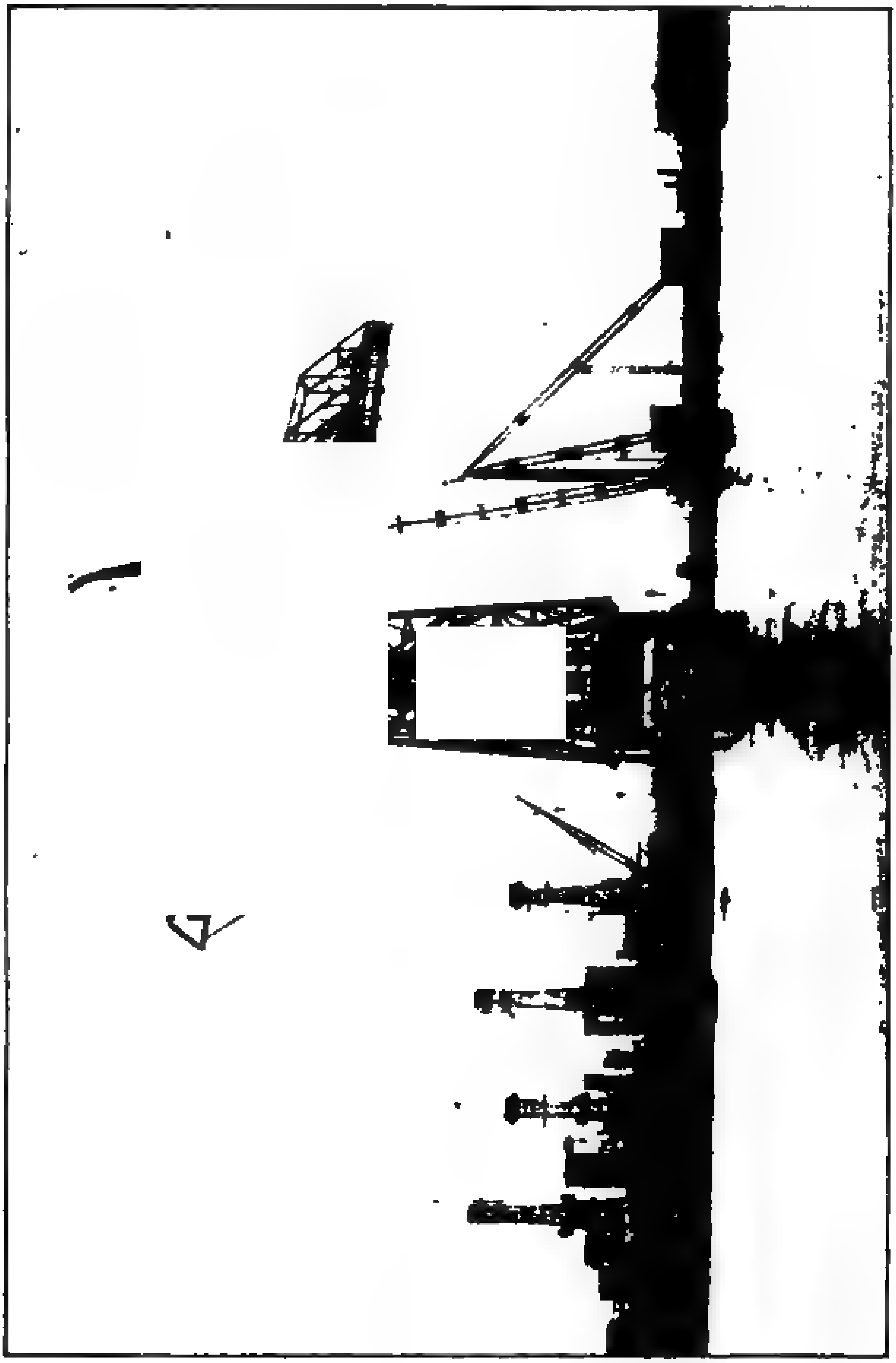
Details.—The forged steel hooks by which the loads are raised have, in the case of the 175-ton hook, a shank 9 inches in diameter, and in the case of the 350-ton hook, a shank 13 inches in diameter. The 50-ton block and load are carried by eight $1\frac{3}{8}$-inch wire ropes; the 175-ton block and load by 16 $1\frac{5}{8}$-inch wire ropes running on 50-inch pulleys, and the 350-ton hook and load by 32 $1\frac{5}{8}$-inch wire ropes. The 350-ton hook is carried from the two 175-ton blocks by a steel equalizing beam 4 feet $10\frac{1}{2}$ inches deep.

The clear lift of the main hook is 141 feet above and 29 feet below the deck of the pier; and of the auxiliary hoist, 151 feet above and 29 feet below. The three trolleys carrying loads in and out on the forward cantilever of the jib operate on separate runways—the one 50-ton trolley to a distance of 190 feet from the center of the tower, and the two 175-ton trolleys to a distance of 115 feet from the center. The two latter are arranged so that they can be coupled together in order to lift, by means of the additional hook and equalizing beam above mentioned, the capacity load of the main hoist, 350 gross tons or 392 short tons.

The forward cantilever is 200 feet long, 40 feet wide from the tower to the limit of travel of the main hoists, and 13 feet 4 inches beyond that. Its trusses have a depth of 40 feet at the tower.

The rear trusses, carrying the machinery house and the counterweight, are 100 feet long and 20 feet deep, and form a cantilever 40 feet wide.

The machinery house itself is a large building—80 feet long, 43 feet wide, and 32 feet high—and contains the machinery for hoisting and lowering the hooks and for racking the trolleys. The two main hoisting motors and the one



Construction view, 350-ton fitting-out crane, Navy Yard, Philadelphia, Pa.

Official test of 350-ton fitting-out crane, Navy Yard, Philadelphia, Pa.

auxiliary hoisting engine are of 87 horsepower each; the two main racking motors and the one auxiliary racking motor are of 27½ horsepower each. The drums on which the ropes for the main hoist are wound are 10 feet in diameter and 14 feet long, and revolve on a shaft 10½ inches in diameter.

The machinery house also carries an overhead traveling crane of the bridge type of 35 tons capacity (determined by the weight of the main drum and drum shaft) for the handling of machinery. The runway on which this crane operates extends through the rear wall of the machinery house a distance of 17 feet. By lowering the rear wall of the house, which is especially designed for the purpose, the crane is permitted to travel out beyond the end of the building in order to transfer parts to and from the pier, about 215 feet below.

The counterweight is of concrete, and weighs 628,000 pounds.

The pintle supporting the rotating part of the structure (jib and "petticoat") is of cast steel, 60½ inches in diameter, and when the crane is loaded to rated capacity, carries a vertical load of 5,834,000 pounds, and takes a lateral thrust due to maximum conditions of wind, loading, and eccentricity, of 607,000 pounds. The vertical load is taken by means of 220 roller bearings, 3 inches in diameter, and the horizontal thrust by 62 rollers, 2 inches in diameter. The metal of the bearing rollers is a high-carbon, high-chromium tool steel with the exceptional ultimate bearing strength of 290,000 pounds per square inch after hardening treatment—raised from 96,000 pounds per square inch before treatment.

The eccentricity mentioned is due to the fact that the jib is designed so that the overturning moment, or the tendency of the jib to overturn, is equal and opposite in direction under each of the two conditions of no loading and maximum rated load; in case of no load on crane, the center of gravity of the rotating mass is 12.45 feet behind that of the tower, and in the case of maximum load, 10.65 feet in front. This tendency toward overturning is resisted by the horizontal bearing of the bottom rim of the "petticoat" on the circular girder encircling the tower legs, as well as by the horizontal bearing at the pintle. The horizontal thrust at the bottom rim of the "petticoat" is taken up by means of 64 26-inch wheels mounted on two chains and bearing on a circular girder 55 inches deep and 64 feet in diameter.

The sluing or revolving mechanism, located at the top of the portal, consists of an 87-horsepower motor with gearing, driving 4 pinions working into a rack 64 feet in diameter, having 768 teeth of 3.1416-inch pitch and 12-inch face.

The operating speeds of the crane are as follows:

	Feet per minute.
Hoisting:	
Main hoist	2½
Auxiliary hoist	15
Racking:	
Main trolley	15
Auxiliary trolley	80

Revolving: One complete revolution in 12 minutes.

All of the operations of the crane are controlled from an operator's cab located under the jib, adjacent to the tower and in full view of all of the handling operations of the crane. The machinery is controlled from the cab by means of master controllers operating solenoid switches located in the machinery house. Clutches for throwing the hoists into high or low gear and for coupling together the main hoists when using the equalizer beam are located in the machinery house and are mechanically operated by levers in the operator's cab.

The structure is designed so that when it becomes necessary to renew pintle bearings or make repairs the entire rotating structure (jib and "petticoat") can be jacked up from the portal by means of four 30-inch jacks of 560 tons capacity each.

The portal has four legs, spaced 56 feet center to center, each of a sectional area of 385 square inches of structural steel, supporting the massive girders 9 feet deep which carry the octagonal tower. The maximum load on one of these legs was computed at 3,000,000 pounds under maximum conditions of wind pressure, and for this load the legs and the foundations were designed. The portal has a clear height of 25 feet 7 inches, which provides ample clearance for locomotive cranes or other equipment on the two tracks passing through it. A power substation which furnishes the electrical current for the operation of the crane is also located beneath the portal.

The entire dead-weight of the crane structure is calculated at 4,000 tons. An uplift of 59,000 pounds being possible in any one leg, due to maximum wind loads on the structure, four bolts 3 inches in diameter are used to anchor each leg to the foundations.

Foundations.—The four tower legs are supported on grillages 10 feet 4 inches square, each made up of two layers of rolled steel girders embedded in massive reinforced concrete caps 35 feet 4 inches square and 9 feet 6 inches deep, tied securely together longitudinally and transversely by the deep reinforced concrete girders of the pier deck. Each of these caps rests on 156 timber piles driven to the hard cemented gravel river bottom and cut off at water level. The piles are supported laterally by an earth fill inclosed and retained by reinforced concrete sheet piles jetted and driven into the hard river bottom. Most of these sheet piles are 18 by 24 inches in section and 52 feet long, weigh about 12 tons, and are tongued and grooved to interlock one with another to form a reinforced concrete wall around the entire foundation, 24 inches thick and spanning from caps and lateral connecting girders to the river bottom.

The crane structure was designed by the McMyler-Interstate Co., of Bedford, Ohio, under the general supervision and in accordance with the specifications of the Bureau of Yards and Docks, and was erected by that company under the supervision of the public works officer at the navy yard. The contract for the crane was awarded to the McMyler-Interstate Co. in January, 1918, and the erection was completed in December, 1919.

The foundations were designed by the Bureau of Yards and Docks and constructed by the Snare & Triest Co., of New York City, as a part of the fitting-out pier. This construction was also under the general supervision of the public works officer.

Auxiliary fitting-out cranes.—The auxiliary cranes are of the same general type as those installed at the Puget Sound shipbuilding dock, but with greater lifts, reaches, and operating speeds and smaller lifting capacity.

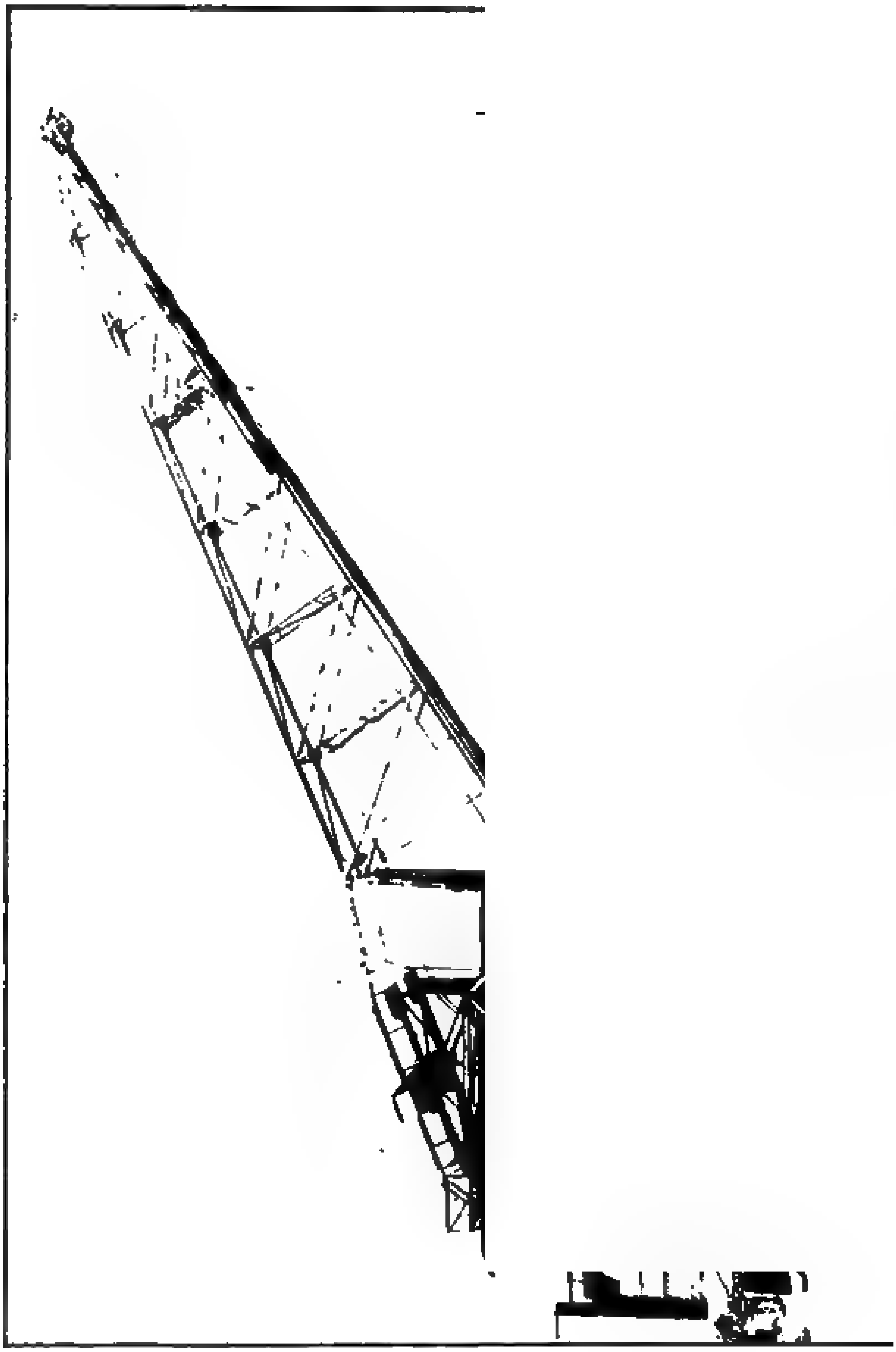
The maximum lift is 130 feet—about 90 feet above the level of the pier and 40 feet below; the reaches and capacities are 5 tons at a radius of 140 feet and 10 tons at 80 feet. The maximum operating speeds are as follows:

	Feet per minute.
Hoisting, 5-ton load	100
Hoisting, 10-ton load	50
Racking, 5-ton load	300
Racking, 10-ton load	250
Crane travel, 10-ton load	200
Rotating, 10-ton load, at maximum radius	300

Three of these cranes, two for the Norfolk pier and one for Philadelphia, have been constructed by the McMyler-Interstate Co.

Fitting-out cranes, Navy Yard, Philadelphia, Pa. Left to right: 350-ton crane; auxiliary travelling crane.

Auxiliary fitting-out cranes nearing completion, Navy Yard, Norfolk, Va.



Locomotive crane (50-ton), Dry Dock No. 4, Navy Yard, Norfolk, Va.

WATER-FRONT AND GENERAL IMPROVEMENTS.

General.—The various main projects under the above head have been touched upon previously, but no mention has been made of the various auxiliary improvements necessary to the efficient operation of plants. Yard railroad systems, streets, and sewers naturally had to be extended on a large scale.

Tracks, streets, and sewers.—At each of the yards—Philadelphia and Norfolk (and at the other yards in proportion to the major improvements)—several miles of new standard-gauge track were laid to serve the new shipbuilding industrial areas and to provide classification tracks for the proper handling of the greatly increased volume of traffic. Of equal magnitude and importance are the extensions to yard streets and to storm and sanitary sewers.

All of this railroad and municipal work has been performed in accordance with the best current practice, modified to suit local conditions. The new streets at the various yards are practically all of permanent construction—vitrified brick, wood block, or concrete, according to the nature of service expected and conformably with preferred yard practice. Concrete pavements are being more and more widely used, because of their suitability and economy in relation to the increasing proportion of rubber-tired traffic.

This work has been performed under a great number of contracts and also, to a large extent, by yard forces.

Water-front improvements.—Because of the costly nature of this work, the time required for its execution, and the lack of sufficient funds, water-front improvements and berthing facilities have not been provided to keep pace with general development, nor have such improvements been at all commensurate with the increase in the Navy afloat. Extensive accommodations of this nature are necessary at most of the shipbuilding yards, particularly New York, Philadelphia, Norfolk, Charleston, Puget Sound, and Mare Island.

The most extensive improvements undertaken in connection with shipbuilding and repair development (aside from the fitting-out piers described above) are at the Norfolk yard, where about 1,300 feet of quay wall of the relieving-platform type, with concrete sheet piles, have been or are now being constructed adjacent to the fitting-out slips. Nearly 1,500,000 cubic yards of dredging has been performed in connection with this improvement.

The quay-wall work and dredging is being executed under contracts with H. P. Converse & Co., who were also the contractors for the fitting-out pier.

MISCELLANEOUS PROJECTS.

FLOATING CRANES.

General.—The typical navy-yard development plan contemplates the provision of floating derricks and cranes of capacities varying from 15 and 20 tons to 150 tons to assist shore cranes in the fitting out of vessels and for use in connection with repairs to ships. A few of the smaller cranes and two of large capacity were provided shortly prior to and during the war.

One hundred and fifty-ton cranes, Norfolk and Mare Island.—Of these floating cranes, the most interesting are the two large revolving cranes constructed for the navy yards, Norfolk and Mare Island. They are of the jib type, with capacities, reaches, and lifts as follows:

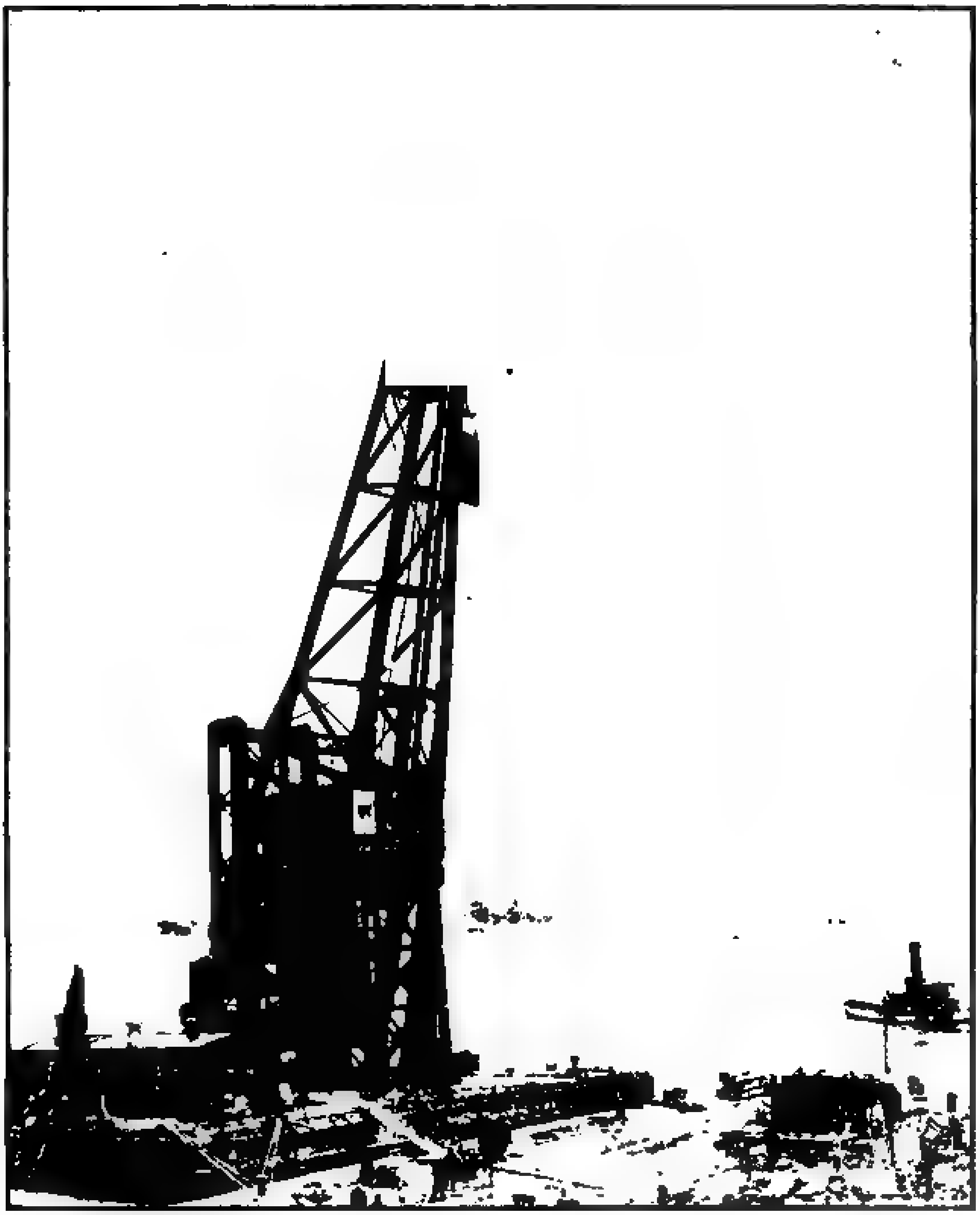
Capacity (gross tons).	At maximum radius (jib in lowest position).		At minimum radius (jib in highest position).	
	Radius	Lift above water.	Radius.	Lift above water.
	Feet.	*Feet.*	*Feet.*	*Feet.*
150......	[1] 105	90	29	146
25......	123	100	34	166

[1] 62.5 feet over side and end fenders.
Lift below water 25 feet.

The steel pontoons of these cranes are 85 feet wide by 140 feet long, with a draft of about 8 feet. Both cranes were designed, to the bureau's specifications, and constructed, by the Wellman-Seaver-Morgan Co., of Cleveland, Ohio. In the case of the Norfolk crane, the contract included the construction of the pontoon; that for the Mare Island crane was built by navy-yard forces. The Norfolk crane was completed in 1917, and the one at Mare Island in 1918.

SPECIAL LOCOMOTIVE CRANES.

Dry-dock cranes.—Principally for use in connection with the new dry docks (described elsewhere), 50-ton locomotive jib cranes have been constructed for yards as follows: New York, 1; Philadelphia, 2; Norfolk, 1; and naval station, Pearl Harbor, Hawaii, 1. Excepting the one for New York, which is steam-operated, all of these cranes are electrically powered. The revolving structure of these cranes is mounted on a portal tower, permitting of the passage of standard-gauge rolling stock on tracks underneath. The working capacities, except for New York, are: Main hoist, 50 gross tons at a



Floating crane (150-ton), Navy Yard, Mare Island, Calif.

Floating crane (150-ton), Navy Yard, Norfolk, Va.

Locomotive cranes (50-ton) for Dry Dock No. 3, Navy Yard, Philadelphia, Pa.

reach of approximately 91 feet, and lift of 65 feet above ground and 50 feet below; auxiliary hoist, 15 gross tons at a reach of approximately 130 feet, and lift of 90 feet above ground and 50 feet below. The reaches for the New York crane are somewhat less because the dry docks at that yard are smaller than those more recently constructed. It is to be noted that a capacity of 50 tons is generally ample for cranes serving dry docks, where overhauls of a relatively minor nature are executed. The capacities of floating and fitting-out cranes are, as has been seen, much larger in important cases.

MARINE RAILWAYS.

General.—In order that the numerous smaller vessels of the Navy (such as patrol boats, submarines, minesweepers, destroyers, gunboats, barges, tugs, etc.) may be conveniently and economically taken out of the water for repairs or overhauling, a marine railway of suitable capacity is an essential part of the equipment of any station whose mission includes the care of such vessels. At a yard where only the larger dry docks are available, a suitable marine railway is desirable because of its economy of operation and the probability of more urgent need of the docks for major vessels; and at a station where docks are not available, the marine railway becomes an indispensable requisite. The shortage of equipment of this nature, both at naval and commercial plants, was recognized prior to the war; and, needless to state, the increases in the Navy of recent years have greatly emphasized this necessity.

Appropriations.—The act of October 6, 1917, contained an appropriation of $350,000 for "Marine railways at navy yards and stations." The naval appropriation acts of March 4, 1913, and July 1, 1918, made specific appropriations for marine railways at the naval station, Pearl Harbor, Hawaii, and the Naval Fuel Depot, San Diego, Calif., respectively. (The naval appropriation act of June 4, 1920, made additional specific appropriations for the completion and increase in capacity of the Pearl Harbor and San Diego marine railways.)

Marine railways constructed.—Under the appropriation first named, marine railways for ships up to 2,000 tons displacement were constructed at the navy yards, Boston, Mass., and Charleston, S. C.

Under the appropriations of March 4, 1913, and July 1, 1918, construction of 2,000-ton marine railways was started at Pearl Harbor and San Diego. In completing these structures, however, the capacity of each is being increased to 2,500 tons, and the latter will be removed from the site at the fuel depot to a much more advantageous

Marine railway, Navy Yard, Charleston, S. C. Cradle submerged.

Marine railway, Navy Yard, Charleston, S. C. Cradle ashore.

location at the recently acquired naval repair station at San Diego. A marine railway of 250-tons capacity was constructed at the Cape May, N. J., section base, and two of 90 tons each were constructed for the section base at Corfu, Greece. These latter were fabricated in the United States, but had not been shipped abroad at the time the armistice was signed. One has subsequently been installed at the naval training station, Newport, R. I., and the other stored at the naval training station, Great Lakes, Ill., where it will be installed as an important auxiliary of the harbor development project authorized for that station.

The Charleston and Boston railways were constructed by the Crandall Engineering Co., of Boston, and Mr. James L. Crandall was of assistance to the bureau in the preparation of the designs of the four large railways mentioned. The San Diego railway is under construction by the Ross Construction Co., of Sacramento, Calif. The Pearl Harbor ways and machinery house were constructed by the Hawaiian Contracting Co., and the cradle and hauling machinery are being furnished under contract with the same concern. The Cape May railway was constructed by Cramp & Co. of Philadelphia. The 90-ton railways were fabricated by the Vanderstucken-Ewing Construction Co., of Bethlehem, Pa.

Characteristics.—The 2,000 and 2,500-ton railways mentioned are all of the same type and, except for length of ways, of the same dimensions. A general description of the design follows:

Ways: The ways consist of built-up wood stringers (set on a slope of about seven-eighths inch per foot), supported by piles; at Charleston, San Diego, and Pearl Harbor there are two inclined runways 16 feet center to center, and at Boston three runways 15 feet center to center. The inshore end of the ways at Pearl Harbor is of concrete construction supported on rock.

Cradle: The cradle consists of a structural steel framework at Charleston, San Diego, and Pearl Harbor, and of timber framework at Boston. All are provided with wood decks and walk ways, and with all necessary fittings, such as keel blocks, bilge blocks, winches, cleats, etc. The cradle travels on two (three at Boston) ranks of rollers, one rank being supported on each runway of the ways. The cradle is constructed in two sections bolted together, making it self-docking for repairs and painting purposes.

Hauling mechanism: The cradle is hauled both in and out of the water by an electrically operated chain hoist housed at the head of the ways. There are four main hauling chains, attached to a drawhead near the center of the cradle. The hauling and back-hauling chains are endless, and are provided with suitable equalizing sheaves to take up unequal strains.

The principal characteristics and dimensions of these railways—as well as of others, new and old, in the naval service—are shown in the following table:

Marine railways at United States navy yards and naval stations.

Yard or station.	Year constructed.	Capacity.	Length of ways.	Length of cradle between extreme keel blocks.	Length of cradle over all.	Width of cradle, clear, between staging.	Width of cradle over all.	Depth of keel blocks to mean high water.
		Gross tons.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Pearl Harbor	1918–1920	2,500	738	332	363	42	52½	18
San Diego	1918–1920	2,500	700	332	363	42	52½	18
Boston	1918	2,000	652	332	363	42	52½	18
Charleston	1918	2,000	729	332	363	42	52½	18
Key West	1910	750	647	161	177	32	42	15
Cape May	1918	500	520	160	172½	26	34½	15½
Guantanamo	1913	500	322	101	109	....	32	15
Washington	1853	500	493	....	211	40	....	12
Newport	1919	90	350	104	110	20	26	7
Great Lakes	Projected	90	350	104	110	20	26	7
Cavite [1]	....	300	....	....	....	....	....	....
Do. [1]	....	100	....	....	....	....	....	....
Do. [1]	....	40	....	....	....	....	....	....
Do. [1]	....	40	....	....	....	....	....	....
Do. [1]	....	25	....	....	....	....	....	....

[1] Data lacking.

CHAPTER IX.

SHIPYARD AND INDUSTRIAL PLANT EXTENSIONS.

GENERAL.

Necessity.—Early in 1917 the Navy found itself face to face with the problem of expediting construction on its war fleet, of which torpedo boats, submarines, and smaller craft in general formed the large mass. This represented actual emergency building, superimposed on the six-year program inaugurated the year before. The process which was to place the United States second in the list of naval powers began at the outset to tax to the utmost the facilities of the commercial shipbuilders, and even to exceed their capabilities of early expansion.

Character of assistance.—It was seen that aid, direct or indirect, would have to be extended to many of these concerns by the Navy itself, and the engineering resources of the department and requisite moneys were made available. The magnitude and character of the requisite plant extensions were determined by the Secretary of the Navy in consultation with and on the recommendation of the chiefs of the bureaus interested. The respective bureaus made the necessary contracts for the construction involved, and were responsible for the proper expenditure of and accounting for funds allotted, except that for all extensions in connection with contracts for ships the Compensation Board was the agency designated by the department to perform some of the functions of this character, as described in the respective ship contracts.

The necessary technical supervision and inspection of work included in these plant-extension projects, especially as to general efficiency of layout and arrangement of detail and inspection of construction work, were assigned to the Bureau of Yards and Docks by the Secretary of the Navy in August, 1917. This authorization applied, in general, to the public-works features to be provided, which covered the major portion of the total cost. Rear Admiral H. H. Rousseau (C. E. C.), U. S. N., was designated project manager for the whole undertaking. Mr. Henry B. Seaman, a consulting engineer of New York City, was called to the bureau to assist in the execution of the projects involved, and resident engineers with necessary assistants were appointed.

This activity of the bureau is not to be confused with its regular work of navy yard improvement, the war-time phases of which have been discussed at some length in the chapter "Shipbuilding and repair facilities."

Cost.—Some 45 projects of this character, involving a gross outlay in excess of $71,000,000, were carried through to successful completion under various contracts. As will be understood from a study of the "rental" agreements explained hereinafter, the above total exceeds by a large amount the net expense of these improvements to the Government, since liquidations will refund a total of more than $30,000,000 in payments and appraised usable equipment. Placing the net outlay (conservatively) at $41,000,000, one is struck with the relative smallness of the sum as compared with the $812,000,000 worth of naval vessels whose construction was either made possible or materially expedited through its expenditure. On this basis less than 6 per cent of the cost of the additional fleet units has actually to be charged to the account of the plant extensions.

Rental agreements.—The extensions financed by the Government to provide for the construction of hulls and machinery can be classed in three general groups, as follows:

(1) Special rentals "A": These facilities are and remain the property of the contractor. Their cost was divided between the shipbuilding contractor and the Navy Department, tentatively, at the time of approving the special rental, and is being finally fixed by appraisal upon the termination of the contract. The Government's share of the cost of these items is allowed as a special rental or depreciation, and is charged to the cost of the ships, but no profit thereon is allowed the shipbuilder.

(2) Plant extensions (under the naval act of October 6, 1917): These belong to the Government, their whole cost being defrayed by the latter. Upon the completion of the work some or all of the items may be taken over by the contractor, as determined by him, at their value as appraised at that time—the others being removed by the Government or abandoned, as the Government may decide. No part of the cost of these items is charged to the cost of the ships.

(3) Special rentals "B": These resemble "plant extensions," in that the Government defrays their entire cost, and that they are and remain the property of the Government. They are subject to the Government's disposal at the conclusion of the contract. They resemble special rentals "A" only in that their cost is charged to the cost of the vessels concerned.

Other extensions were financed by the Government on lines similar to the above.

Projects.—The plants whose facilities were increased through naval assistance are tabulated below, together with the construction calling for added facilities, and the expense involved in each extension:

Plant.	Construction making extension necessary.	Approximate cost of extension.
obile, Ala.	3 minesweepers	960,434.53
altimore, Md.	7 minesweepers	128,117.35
	11 destroyers	417,768.28
	4 minesweepers	106,662.65
ng Co., Phila- .	Various vessels	4,404,210.98
	Equipment for destroyers	1,248,748.54
	Various vessels	1,500,000.00
	Submarines	192,552.90
	100 Eagle boats	3,500,000.00
	do	2,000,000.00
, Mass	Various vessels	2,796,520.32
ass	Transportation improvements.	494,000.00
, Mass	35 destroyers	13,737,285.00
. Y	35 turbine sets for destroyers	2,907,000.00
, R. I	112 Yarrow boilers for destroyers.	1,052,500.00
Worthington Pump & Machinery Co., East Cambridge, Mass.	150 sets pumps for destroyers	2,897,633.00
Falk Co., Milwaukee, Wis	Gears for destroyers	800,000.00
Sturtevant Co., Hyde Park, Mass	Turbine sets for destroyers	190,000.00
Edward Valve Co., East Chicago, Ind	Valves	140,000.00
Chapman Valve Co., Indian Orchard, Mass	do	20,000.00
Consolidated Mfg. Co., Bridgeport, Conn	Safety valves	68,000.00
Gas Engine & Power Co., Morris Heights, N. Y	5 minesweepers	156,253.92
Griscom Russell Co., Massillon, Ohio	Equipment for destroyers	325,000.00
Lake Torpedo Boat Co., Bridgeport, Conn	12 submarines	423,305.52
New Jersey Dry Dock & Transportation Co., Elizabethport, N. J.	3 minesweepers	72,188.80
Newport News Shipbuilding & Dry Dock Co., Newport News, Va.	Various vessels	9,323,773.00
New York Shipbuilding Corporation, Camden, N. J	do	4,043,773.48
Pennsylvania Shipbuilding Co., Gloucester, N. J	2 minesweepers	14,971.82
Pusey & Jones Co., Wilmington, Del	do	7,583.75
Staten Island Shipbuilding Co., Staten Island, N. Y	8 minesweepers, 6 seagoing tugs.	1,175,320.64
Sun Shipbuilding Co., Chester, Pa.	3 minesweepers	8,230.60
Bethlehem Shipbuilding Corp, (Union), Potrero-Alameda, Calif.	Various vessels	1,668,010.12
Potrero-Alameda	do	2,668,800.00
	do	135,000.00
	4-inch gun forgings	375,111.51
	Coal storage	324,800.00
	Gun forgings	210,771.00
y, Md	500 4-inch guns	535,360.00
	250 antiaircraft-gun mounts	159,810.39
	Gun forgings	1,800,000.00
	Coal storage	382,254.00
sland	Airplane propellers	229,385.65
	4-inch gun forgings and destroyer shafting.	7,700,998.00
Allis-Chalmers Co., Milwaukee, Wis	Rotor drums and destroyer shafting.	557,106.00
Pollock Steel Co., Cincinnati, Ohio	Gun forgings	732,600.00

Thirty-four of the foregoing plants were engaged in the construction of torpedo-boat destroyers, scout cruisers, submarines, minesweepers, and accessories for these vessels, and of the Eagle boats (built by the Ford Motor Co.), two have provided for the storage of coal; one for the production of airplane propellers, and eight for the production of shafting and ordnance material. Many of the above plants were substantially completed and used in the calendar year 1917, and practically all of them were in successful operation before the expiration of the fiscal year 1917–18. The three largest

plants were the torpedo-boat-destroyer plant of the Bethlehem Shipbuilding Corporation (Ltd.) at Squantum, near Quincy, Mass., costing nearly $14,000,000; the extension to the plant of the Newport News Shipbuilding & Dry Dock Co., costing over $9,000,000; and the Erie Forge Co. plant, at Erie, Pa., costing nearly $8,000,000.

PARTICULARS OF PROJECTS.

Squantum plant.—The plant proper occupies about 97 acres of land at the north end of a tract of 700 acres, commandeered by the Navy Department, located about 5 miles north of Quincy, at the mouth of the Neponset River. It consists of a fabricating and assembling shop, with 10 building slips under roof, and 6 wet berths, also under roof, and the necessary auxiliary shops, storehouses, wharf, wet basin, launching ways, railroad tracks, streets, street railway connections, etc. The plant is adapted to the rapid construction of light-draft hulls and the installation of the machinery and fittings for such vessels. It is entirely Navy owned. This plant was authorized October 6, 1917; construction work began immediately and progressed during a winter of extreme severity. The fabrication of the shipwork by the Bethlehem Shipbuilding Corporation (Ltd.) began at the plant in January, 1918; five keels were laid in April, the first boat was launched in July, and delivered to the Navy on November 30, 1918. The plant was substantially completed in May, 1918, seven months after it was authorized. Up to May 1, 1920, 35 destroyers had been built and launched at this yard by the Bethlehem Shipbuilding Corporation (Ltd.), of which 33 were entirely completed. This plant has been turned over to the jurisdiction of the commandant, navy yard, Boston, for ultimate use as a repair base for destroyers and submarines. It is designated as the "United States destroyer and submarine base, Squantum, Mass." In connection with destroyers constructed at this plant the department constructed a boiler shop at Providence, R. I., and a turbine shop at Buffalo, N. Y., both of which were also operated by the Bethlehem Shipbuilding Corporation (Ltd.) in conjunction with the Squantum plant. The turbine shop furnished 35 sets of turbines for the destroyers built at Squantum, and the boiler shop furnished the boilers and the condensers. The structural part of the turbine shop, constructed at Buffalo, N. Y., has been sold, and the tools have been transferred to navy yards. The boiler shop at Providence has been transferred to the city for the fiscal year 1920–21 for use as a receiving, storage, and transit station in connection with the operation of a proposed steamship line between Providence and other points, reimbursement to the Navy Department to be in the sum of $10,000. The building will ultimately be removed to South Boston to the naval dry-dock property.

Squantum destroyer plant. General view during construction.

Shore end of building slips at Squantum destroyer plant.

Wet slips and building slips at Squantum destroyer plant.

Interior view of wet slip, Squantum destroyer plant.

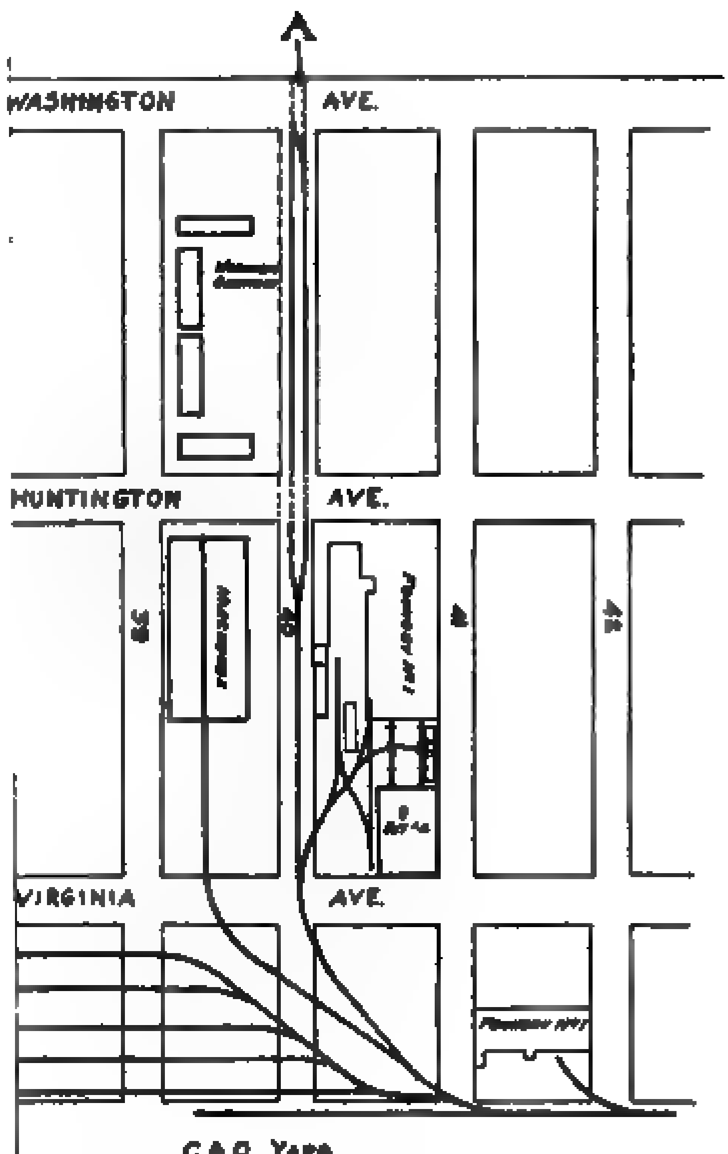
Newport News Shipbuilding & Dry Dock Co.—This plant occupies approximately 120 acres, and the yard consists of 13 shipways, 3 of which are being used for battleships and large commercial vessels; 2 ways, not yet completed, will be used for battle cruisers; and 8 ways are used for destroyers. There are three dry docks—No. 1 is 600 feet long and 90 feet wide; No. 2 is 800 feet long and 95 feet wide; No. 3 is 525 feet long and 100 feet wide. The plant also includes the necessary buildings, yards, and equipment for light and extra heavy shipbuilding work. Before the additions were made to the yard through the use of Navy funds, there were seven ways, and these were large enough to build any vessel up to and including the largest battleships of the type of the *Mississippi*. There were no ways available for battle cruisers, nor for laying down the large number of destroyers which the yard had been ordered to build.

The Navy contract calling for the emergency plant extension was for the construction of an additional number of destroyers, making a total of 31 in all. The total estimated cost of the Navy contracts for the 31 destroyers, 2 battle cruisers, 2 battleships, 8 tankers, and 2 troopships is nearly $150,000,000. The total cost of special rentals and plant extension authorized on account of these items amounts to approximately $10,000,000. The United States Shipping Board Emergency Fleet Corporation had in addition contracted with the Newport News Shipbuilding & Dry Dock Co. for some tankers and troopships, and had authorized new plant extensions to the extent of $800,000.

The Navy plant extension consists of a large addition to the north end of the old yard, upon which a large amount of dredging had to be done, a sea wall built, and four shipways with connecting railways and handling facilities constructed. These four shipways are known as Nos. 10 and 11, each unit having two shipways under its respective number. There were also various smaller items of equipment and tools. These ways added to the facilities of the yard so that more destroyers could be worked upon. Shipways Nos. 8 and 9 are large ways 900 feet long, with submerged outer ends protected by caissons and served by very high towers supporting runways carrying heavy electric cranes, and also by a complete layout of angle and plate yards, with the working shops for these materials and handling facilities for the ways. These two latter ways and the extension to Pier No. 1 will not be completed before the middle of the calendar year 1921. Construction of this plant extension work began in 1917 and is all in use with the above exceptions. Title to the plant extension is to be transferred to the shipbuilding company upon completion of the destroyers, in accordance with an agreement already executed. There will remain outstanding at this plant as the property of the contractor a large number of "special rental"

Ship fabricating shed, Navy extension to plant of Newport News Shipbuilding and Dry Dock Co., Newport News, Va.

General view of Navy extension to plant of Erie Forge Co., Erie, Pa.



GENERAL LAYOUT
IPBUILDING PLANT
NEWPORT NEWS
SHIPBUILDING & DRY DOCK CO.

items allowed in connection with contracts for battleships and battle cruisers.

Erie Forge Co.—This plant, located at Erie, Pa., was designed for the manufacture of 4-inch gun forgings, rotor drums, and destroyer shafting, and contracts with the Navy Department called for the production by the Erie Forge Co. of 7,500,000 pounds of forgings and 7,500,000 pounds of drums and destroyer shafting. The plant cost approximately $7,700,000. Work was started early in November, 1917. The extension consists of four main buildings, as follows:

	Feet.
Open-hearth building	171 by 280
Forge shop	201 by 364
Machine shop	195 by 360
Heat-treatment building	67 by 336

There are also a number of miscellaneous buildings, including a substation, boiler house, administration building, chemical laboratory, physical laboratory, office building, etc. The open-hearth department includes in its equipment two 50-ton furnaces with all accessories. Rapid progress was made on this plant extension, and it was substantially completed and in operation by the Erie Forge Co. before the expiration of the fiscal year 1917–18, or less than eight months after it was authorized.

Ford Motor Co., Detroit plant.—The shipbuilding plant was an entirely new proposition for the Ford Motor Co., and was constructed on the north end of a plat of ground primarily intended for blast-furnace operations, upon the south end of which the blast furnaces have now been erected. The plat of land is about 1½ miles long by three-fourths mile wide, and fronts at the lower end on the River Rouge and Roulo Creek. The latter waterway was dredged out and extended to form a launching slip and fitting-out berths.

No building ways were used in connection with the construction of the Eagle boats. A conveyor system of trucks was used to move the hulls from one operation to another, there being in all seven stations on each of three lines of track. Standard-gauge car-wheel trucks, with heavy timber platforms mounted thereon, were used for conveying. The hulls, when completed, were hauled upon a transfer table at the lower end of building "B" (marked "K" on plan), and then transferred to the hydraulic launching device ("L"), which lowered the hull into the water.

Building "A" is a steel and brick building with wood trusses, used for the fabricating shop, the material thence being moved to building "B," also built of structural steel and brick. The buildings "C," "D," and "E," of standard "Truscon" construction, are used as storehouses and fitting-out shops; building "C" is essentially a storehouse, while "D" and "E" were used for both storehouses and

fitting-out work. The shaded surfaces shown on the print indicate the portion of the plant devoted to Navy work.

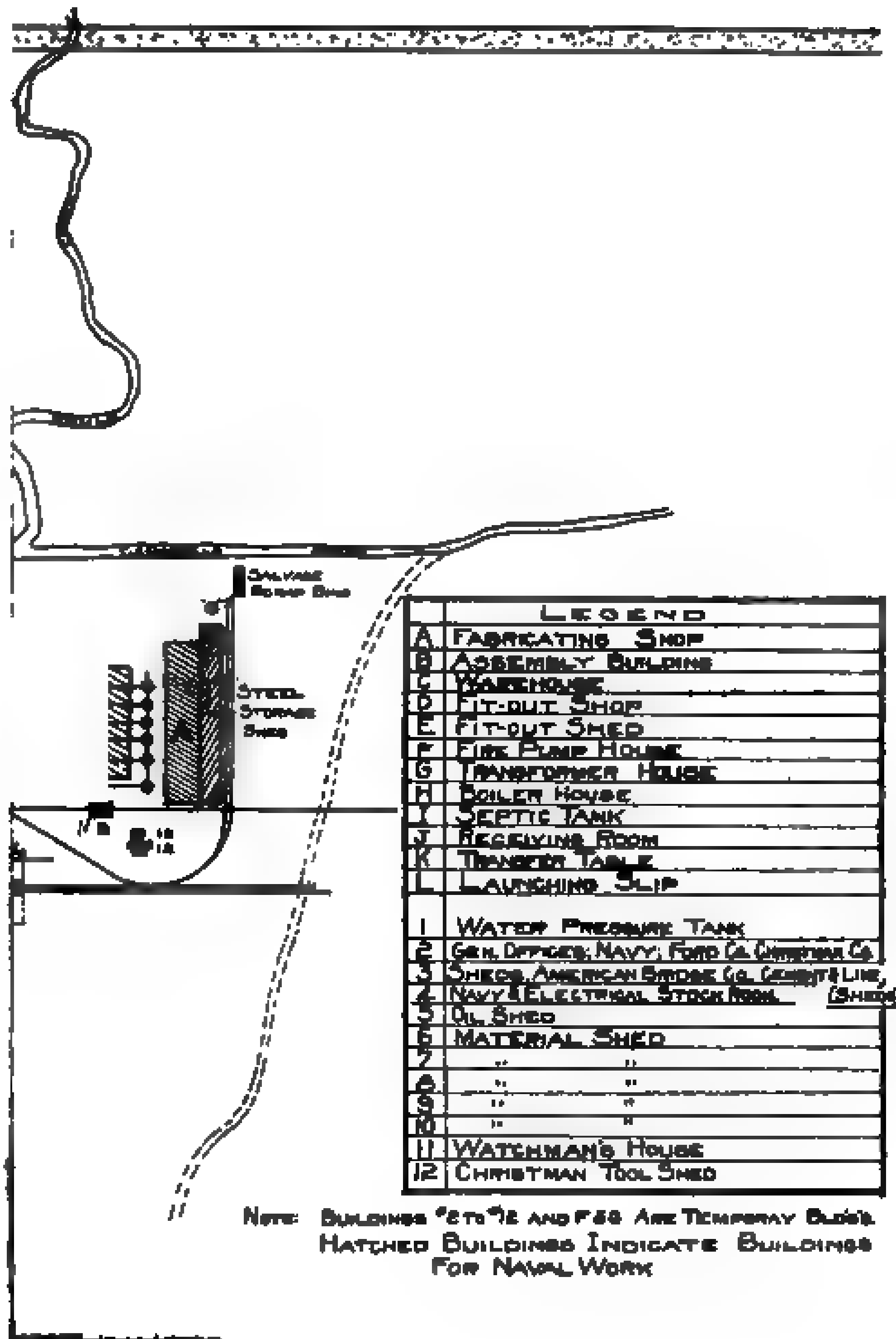
The contract for the construction of patrol boats originally called for 100 boats, each of about 500 tons displacement, 200 feet long, turbine driven, with Poole reduction gear, fuel-oil burning, equipped with boilers of the Bureau of Engineering "Express" type, mounting one 4-inch and two 3-inch guns, and carrying depth-charge launching gear and "Y" gun. This contract was later increased to 112 boats, the additional 12 being on account of the Italian Government, the United States Navy Department paying all bills and supervising the construction of the boats and being reimbursed by the Italian Government.

After the signing of the armistice this contract was reduced to 60 boats, that figure having been determined upon by the Bureaus of Construction and Repair and Engineering as being the most economical point at which construction could be cut off. The boats were built under a cost-plus fixed-profit contract, at an estimated cost of $275,000 each, providing for a bonus to the contractor for any savings on this amount. It was later estimated, however, by the technical bureaus that these boats would cost about $500,000 each, making a total contract of $30,000,000 for the 60 boats.

The actual cost to the Government of this plant extension is estimated to be $5,500,000. Inasmuch as the plant was entirely constructed for the purpose of building ships for the Navy, no other work was done for other departments of the Government. At the motor-car plant at Highland Park the turbines, boilers, condensers, and evaporators have been either assembled or constructed, but no addition to plant, such as would come under the cognizance of the Bureau of Yards and Docks, has been made at that plant. The greater part of the River Rouge plant extension was sold to the Ford Motor Co. Small portions of the installation were transferred to navy yards or sold to other parties.

New York Shipbuilding Corporation.—This plant is located at Camden, N. J.; the total area covered is 182.8 acres, with 10 single and 11 double shipways. The Navy plant extension covers an area of 15.5 acres, containing four uncovered and six covered ways with appurtenant plate-and-angle shop, etc. The entire yard covers a water front of 3,917.8 feet. The Navy contracts for the first 10 destroyers and for 20 additional ones, together with the contract for 2 battleships and 1 battle cruiser, amount to approximately $90,000,000.

The Navy plant extension, which was constructed for the building of destroyers Nos. 231 to 250, inclusive, is located at the south end of the original yard, and is bounded on the south by Newton Creek and on the west by the Delaware River. At the beginning of the



—— GENERAL LAYOUT ——

EAGLE BOAT PLANT

FORD MOTOR CO.-RIVER ROUGE, MICH.

SCALE

200' 0 200' 400' 600'

1 INCH = 200 FEET

37022—21. (To face page 224.)

Building "B," Navy extension to works of Ford Motor Co., River Rouge, Mich.

Machine shop, Navy extension to works of Wellman-Seaver-Morgan Co., Akron, Ohio.

Navy extension to plant of New York Shipbuilding Corporation, Camden, N. J.

work practically all of this area, being marshland, had to be reclaimed. This was done by throwing up a mud bank and filling behind it with dredged fill taken from the mouth of Newton Creek. Along the Delaware are constructed the shipways, which consist of four uncovered ways each 43 feet wide by 325 feet long, with a 25-foot wharf between, and having a frontage of approximately 300 feet. Directly to the south and adjoining are six covered ways having a frontage of 308 feet. Each of the covered ways is fed by an overhead electric traveling crane, while the uncovered ways are supplied by means of tower "whirlers," which travel along the wharves between shipways. Directly inboard of the shipways, but with a 135-foot storage space intervening, is located the steel-frame plate-and-angle shop, covering an area of 101,139 square feet. The original building was destroyed by fire on the night of the 15th of September, 1918, and has since been rebuilt. The remainder of the Navy extension consists of a galvanizing plant, shelter, tool and office building, substation, paint store, storehouse, 101-foot extension to general warehouse, 135-foot extension to machine shop, extension to pipe shop, wharf at Newton Creek, fitting-out wharf, and extension to main power house, together with necessary roadways, railroad tracks, fire-alarm system, and miscellaneous yard equipment such as locomotive cranes, saddle-tank locomotive, etc. There have also been authorized several special rentals of miscellaneous nature. The total estimated cost of the Navy plant extension is approximately $4,000,000. The United States Shipping Board Emergency Fleet Corporation has also assisted this shipyard with emergency plant extensions and additions to old plant to the extent of $14,827,150, the purpose being to rush to completion the construction of troopships under contract with this company. The plant extensions and special rentals of the New York Shipbuilding Corporation are awaiting completion of contracts for ships before being disposed of.

Bethlehem Shipbuilding Corporation, Union Plant, San Francisco.—This plant is composed of two parts, the first being the Potrero yard of the Bethlehem Shipbuilding Corp., the second the Risdon yard, United States Navy. In connection with these plants, a separate yard across the bay, known as the Alameda plant, is operated by the same corporation. The Risdon yard adjoins the Potrero works on the south. The area of the Risdon yard is about 30 acres, with a water front of about 1,700 feet. There are, in this yard, seven building slips, six of which were used for destroyers, from each of which a vessel could be launched every three months. There is also a fitting-out wharf consisting of two parallel piers and a wharf, thus leaving two slips, over which are fitted traveling gantry cranes. Eleven destroyers can be berthed at these piers at one time, eight of

which are capable of being served by the cranes. Two other small berths are provided for handling material, etc. The principal shops consist of the following: Plate shop, sheet-metal shop, blacksmith shop, condenser shop, boiler shop, pattern shop, and galvanizing plant. Prior to the use of this plant in connection with Navy work it was used by its owners, the United States Steel Products Co., for warehousing structural steel and other steel manufactures.

Adjoining the Risdon yard on the north and west are the Potrero works of the Bethlehem Shipbuilding Corp. (Ltd.). This yard is the original Union Iron Works yard, and covers about 24 acres along a water front of some 1,200 feet. It is equipped with five shipbuilding slips, each about 430 feet long by 60 feet wide, together with four fitting-out wharves having an aggregate available berthing length of about 4,200 feet. There are also two floating dry docks of 3,000 and 6,000 tons capacity, respectively. This plant is equipped with a plate shop, machine shop, blacksmith shop, iron and brass foundries, boiler shop, galvanizing plant (supplied by the Navy Department as a special rental "B"), pattern shop, and other small shops and warehouses, including one four-story steel-concrete warehouse. Adjoining this plant, but on separate property, a cafeteria has been provided for the workmen as an item under the Navy plant extensions. There are also three areas of leased land aggregating about six acres, which have been fitted up for storage purposes and for the assembling of frames, bulkheads, and other destroyer and submarine parts. This land also comprises a Navy "plant extension."

The Alameda plant occupies a site of about 75 acres located on the south side of the Oakland estuary, the channel leading from the east side of San Francisco Bay between Oakland and Alameda. This plant has a water frontage on the estuary of about 4,000 feet. The works form a new project of the Bethlehem Shipbuilding Corp., having been reconstructed as a shipbuilding plant in 1916 and 1917. Prior to the commencement of work on Navy contracts this yard was provided with a machine shop, plate shop, electric shop, power house, and other minor shops. There were also four slips, each with a capacity for cargo vessels up to a displacement of 12,000 tons, two small marine railways, a 250-foot floating dry dock, and two wharves for berthing and fitting-out purposes. The Navy plant extensions consisted of the erection of a modern steel-frame brick and concrete machine shop building under special rental "A"; equipping the above shop with cranes and machine tools under special rental "A"; and furnishing additional machine-tool equipment to this shop under plant extensions. It is known as the Alameda turbine shop, and was authorized for the purpose of handling the construction of

turbines for the torpedo-boat destroyers built at the Risdon and Potrero yards.

The Navy contracts at these plants of the Bethlehem Shipbuilding Corp. called for 66 destroyers, 12 "S" type submarines, 2 scout cruisers, and 6 submarines of the "R" type. The total estimated cost under these contracts was $132,900,000. The estimated cost of the special rentals and plant extensions was approximately $3,000,000. The effect of the furnishing of these Navy facilities was to double the productive capacity of the plant for destroyers and submarines, and to provide equipment for handling practically every kind of work which arises on contracts for these classes of vessels. The plant extension at Alameda was necessitated by reason of inadequate shop facilities at the Potrero yard for handling the machine work for turbines and other large jobs in connection with the destroyer contracts.

In connection with the above yards there is operated also the Union Iron Works Dry Dock Co.'s properties at Hunters Point, about 3 miles south of these yards on San Francisco Bay. At Hunters Point there are two dry docks, 750 and 1,000 feet in length, respectively. Under a contract dated February 24, 1916, authorized by act of Congress of June 30, 1914, the Navy Department has prior use of these docks in time of war for six years from the time of completion of the larger dock. The Navy Department obtained a rate of 6½ cents per ton of displacement per day for vessels docked, but is subject to a minimum charge of $50,000 per year from time of acceptance.

The United States Shipping Board Emergency Fleet Corporation financed plant extensions at the Alameda plant to the extent of about $1,500,000. This included the cost of two shipbuilding slips, a marine fitting-out shop, office building, angle shop, a wharf extension, air compressors, machine-tool equipment, pipe lines, etc. The purpose of this work was the expansion of facilities for the construction of cargo vessels. For work in conjunction with this yard, the Emergency Fleet Corporation also authorized the so-called Liberty plant, located on an area of about 160 acres immediately adjacent to the Alameda yard. This plant was to have had eight ways, with complete foundries, plate shops, pattern shop, etc., but was to use the large machine shop of the Alameda plant, referred to above, as its turbine shop jointly with the Alameda plant. The signing of the armistice led to the abandonment of the Liberty yard after the expenditure of about $3,000,000.

These plant extensions for the Navy are awaiting completion of contracts for ships before being disposed of.

Bethlehem Shipbuilding Corporation, Fore River Plant, Quincy, Mass.—The Fore River plant is located at Quincy Point, on the west shore of the Weymouth Fore River. It is a fully equipped shipyard and plant for the construction of all classes of steel ships and contains about 117 acres, of which 85 acres are land and 32 acres are water inside the established harbor line. About 20 acres of the 117 are owned by the Commonwealth of Massachusetts and leased to the Fore River Shipbuilding Corporation at an annual rental of $5,000 for a term of 20 years beginning in 1916.

There are 20 building ways, classified as follows: Four destroyer slips, 10 submarine slips, 5 general slips, 1 battle-cruiser slip. The submarine slips are, in general, long enough to contain two or three submarines per slip and can also be used for destroyers or other light craft. The general slips are suitable for battleships or for merchant ships up to 600 or 700 feet in length. Most of the building slips are equipped with overhead traveling cranes running on steel trestles, but the destroyer slips have locomotive cranes on elevated tracks. The general slips are partly roofed over, but all others are entirely in the open. The battle-cruiser slip and the four destroyer slips are located on the land leased from the State, as are also warehouses Nos. 3, 4, and 5, and gatehouse No. 17.

The yard is nearly cut in two by Bents Creek, an estuary some 350 feet wide, and fitting-out wharves have been built on both sides of this waterway. A smaller fitting-out slip located near-by is used largely for submarines, but is available for craft up to about 400 feet in length. The south wharf is served by a heavy jackknife locomotive crane, and the north wharf by a revolving-jib tower crane with fixed location.

Fabricating and bending of all kinds, brass founding, turbine manufacturing, boiler making, and machine work of all kinds are done in the various shops, but no heavy forging nor iron founding. Shafts, anchors, chains, and most of the drop forgings required are obtained from the Bethlehem, Pa., shops or from outside firms. Pumps and other special equipment are also bought outside. A standard-gauge railroad branch connects the yard-track system with the New York, New Haven & Hartford Railroad near Braintree, so that bulk shipments can be made to any portion of the yard. Before the beginning of plant extensions, etc., by the Navy, the plant had for several years been building battleships, destroyers, submarines, cruisers, etc., and a great variety of commercial craft.

The Navy contracts called for various classes of vessels of which, up to April 21, 1919, 32 of the destroyers had been launched and 24 delivered to the Navy; 10 of the submarines had been launched and 5 delivered. The total cost of all contracts is estimated to be $116,-400,000.

Boiler shop of Bethlehem Shipbuilding Corporation (Ltd.), at Providence, R. I.

Turbine shop of Bethlehem Shipbuilding Corporation (Ltd.), at Buffalo, N. Y.

The general purpose of the Navy extensions was to enlarge the yard's capacity rather than to change its arrangement or the character of its output. A building slip for battle cruisers and four slips for destroyers were added near the south boundary of the yard, and three slips for submarines were added near the north boundary—these submarine slips being allotted to the Electric Boat Co. Two wooden office buildings, five storehouses, one machine shop, additions to the boiler shop, a galvanizing plant, two small gate houses, an electric substation, a charge house, a concrete wharf, a first-aid station, and a timber bulkhead were also constructed, certain dredging was done, and a large amount of machinery and other equipment was provided. In addition to the above work, which was arranged for through the Compensation Board, a fuel-oil school was built and equipped by the Bureau of Engineering. The cost of this plant extension was $151,000; of special rentals "A," $794,607.86; and of special rentals "B," $1,171,515—a total of $2,117,122.86. There will be some salvage on plant extensions and rentals "B," as they are to be appraised at the end of the contract, and are to be sold to the best advantage of the Navy. Under rentals "A," there may be a salvage return or there may be a further charge, depending upon whether the actual depreciation is less or greater than the sum advanced by the Government.

The expenditure of Navy funds has resulted in an increased total capacity for the yard and a large increase in the speed of production of destroyers and submarines. The construction of the battle-cruiser slip has made it possible for the yard to undertake the construction of that class of ship. Since the expenditures began, 32 destroyers and 10 submarines have been launched, as above noted, in addition to several large craft for the Emergency Fleet Corporation. Many of the destroyers were in active service during the war.

The Emergency Fleet Corporation expended about $32,000 in connection with an electrical substation, about $55,000 in connection with a temporary bridge at Neponset used by the Bay State Street Railway, and about $25,000 in connection with repairs and maintenance of rolling stock. This was all for the Bay State Railway Co., which furnishes transportation for workmen coming from Boston and Quincy to the shipyard, and may be considered as assisting the operation of the plant. Other than this, extensions have been provided entirely by the Navy. The project for widening and double-tracking Washington Street, Quincy, at a probable total cost of $494,000, may be considered as indirectly a part of this project, as it was instituted entirely to provide transit for workmen for the Fore River yard.

Wellman-Seaver-Morgan Co., Akron, Ohio.—This plant is situated in the southwest corner of the city of Akron, on a tract owned by

the company, of about 43 acres. The Navy contract of the Wellman-Seaver-Morgan Co. is made up of subcontracts between that corporation and Wm. Cramp & Sons Ship & Engine Building Co., Philadelphia, Pa., the Newport News Shipbuilding & Dry Dock Co., Newport News, Va., the New York Shipbuilding Corporation, Camden, N. J., and the American Engineering Corporation, Philadelphia, Pa. The product under the Navy contract embraces condensers, tanks, steering engines, and other parts for torpedo-boat destroyers, for tank ships, and for the battleships *West Virginia* and *Maryland.*

The emergency plant extension embraces buildings, machine tools, and equipment necessary to enable this plant, which had theretofore been turning out highly specialized or individualized machines, to engage in quantity production of standardized parts of torpedo-boat machinery. The cost of the extension was $1,246,718.54. The Navy expenditures increased the productive capacity and scope of the plant to such an extent that about 95 per cent of the product of the Navy contract was turned out by the new shops; and the fact that the plant was well and adequately equipped for this work is evidenced by the fact that the Navy product was turned out ahead of schedule.

Navy coal-storage plants, Virginian Railway, Sewalls Point, Va., and Chesapeake & Ohio Railway, Newport News, Va.—The necessity for these coal-storage plants became evident early in the war, owing to the probability of freezing of the coal in cars during the winter months, the necessity of an uninterrupted supply of coal for Navy vessels and those operated by the Army, and the hazards of accidents and strikes at the mines or on the railroad.

The land on which the plant of the Virginian Railway is located consists of 42.6 acres. The capacity of the storage plant was estimated as 300,000 long tons of Navy coal, to be stored in flat piles not exceeding 15 feet in height and so accessible as to be readily rehandled. The plant consists of a wooden trestle about 3,240 feet in length, from which the coal is dumped. The area for storage was leveled off, and the coal is rehandled on this storage area by one large double-cantilever electrically operated crane; this crane being also used to rehandle the coal into cars which are to be dumped from the railroad's water-front pier into the holds of vessels. The rate of delivery over the railroad's present pier on the water front is 6,000 long tons per 24-hour day. There was no Navy coal-storage pile on the Virginian Railway prior to the installation of this plant, all coal being held at the terminal in cars.

The contract entered into by the Navy Department with the railroad stipulated that the plant as described should be built by the railway on its own property, the land being leased at $1 per year to the Government. The Virginian Railway Co. agreed to construct

the plant as per specifications, and in accordance with plans submitted by them and approved by the Bureau of Supplies and Accounts, for a lump-sum price of $382,254. The payment for the plant began when the plant was ready for storing the first one-third of the designed capacity of coal. Payments for the plant were made in 12 monthly installments. Upon the completion of the last payment the title to the plant and all equipment was transferred to the Government and the contract was terminated. The railroad is paid a specified price for dumping and for the operation of the storage pile, and is also paid a specified price for all coal delivered from storage; also other items for handling coal in vessels. The records of the cost of the plant were submitted for the information of the Bureau of Supplies and Accounts upon termination of the contract.

After the construction of the coal storage plant was contracted for by the Virginian Railway Co. the railway was taken over by the United States Railroad Administration, and the officials of the Railroad Administration assumed responsibility under this contract.

The Virginian Railway carried on the construction of the plant with a great deal of forethought and energy, but labor conditions around Hampton Roads became so serious that they were unable to hasten the completion of the work as much as they would ordinarily have been able to do. Completion was also delayed on account of the improvements called for by the Railroad Administration, such as double-tracking and extensions to their yards.

The coal storage plant built by the Chesapeake & Ohio Railway Co. is located at Newport News, Va. The plant occupies 43.3 acres of land situated near the main line of the Chesapeake & Ohio Railway. The plant, in general, consists of two locomotive cranes of 101-foot radius, steam-operated, working on tracks running longitudinally with the unloading trestle. The length of the latter is about 1 mile, and it is fitted with aprons for spreading the coal on either side, this coal being rehandled by the locomotive cranes into flat piles about 15 feet high. In this way about 275,000 tons of coal are stored. The cranes also reload coal into cars on tracks parallel to the crane tracks.

The contract was with the Chesapeake & Ohio Railway Co. for a lump-sum price of $324,000. Payments began when one-third of the designed area was ready to receive and issue coal, and continued thereafter in 12 monthly installments. The railway company was required to inform the Government, upon the completion of the storage, of the actual cost of construction. Payments for the operation of the plant in receiving and reloading coal are also fixed in the contract on a per-ton basis. The title of the plant remained vested in the railway company until it was accepted and the last payment made by the Government. The plant is situated on land leased

from the Chesapeake & Ohio Railway Co., and in case the Government wishes to purchase said land, the Government has an option on it at $4,000 per acre. The plant is able to receive or issue 6,000 tons of coal per 24-hour day, and the railway's equipment at the water front is able to handle this quantity into vessels alongside the coal pier.

As in the case of the Virginian Railway, the Railroad Administration and its officials assumed the responsibilities of this Navy contract.

On account of the extraordinary amount of work that the Chesapeake & Ohio Railway had to do in connection with handling freight for and in connection with the port of embarkation, work on this contract was more or less affected and final completion delayed.

Both of these coal storage plants belong to the Navy Department at the present time. The land upon which they are built is leased from the respective companies, but the Bureau of Supplies and Accounts has recommended in its estimates that the sum of $100,000 be appropriated for the purchase of the two tracts of land.

CHAPTER X.

DRY DOCKS.

For the construction of ships, building ways of some description are the first essential; for the upkeep and repair of a fleet after launching a system of dry docks is equally indispensable. The importance of the latter class of facilities is indicated by the name of the Bureau of Yards and Docks itself, covering a period of nearly 80 years, and coexistent with the life of the present Navy Department.

In general, a dry dock is a device for exposing the entire hull of a vessel for purposes of cleaning or repair. Two main types of dry docks are recognized, namely, floating and graving. A third class of apparatus, known as marine railways, or hauling-out ways, is used for hauling small ships bodily ashore for work on their hulls. The latter group is treated in another chapter of this history.

Floating docks have been used to only a limited extent by the United States for naval purposes. One such dock has had a long period of useful service at the naval station at New Orleans, and another, the *Dewey*, famous for its eventful voyage to the antipodes 15 years ago, is still in active commission.

It is with graving docks that the bureau has had to deal more largely throughout its career, and the developments in this class during recent years have been noteworthy. A graving dock is essentially a basin, lined usually with masonry, excavated to accommodate hulls of given dimensions, plus adequate working space. This basin has access to deep water through a gateway which may be closed by some suitable device (generally, in American practice, by a floating caisson conforming exactly, along its longitudinal profile, to the opening). A ship having been floated into the dock, the caisson is put in position and the dock basin is emptied by pumps installed as part of the equipment, and the ship gradually settles on the keel and bilge blocks, which have been previously placed in conformity with her particular lines. In this manner access is gained to the underwater portion of the vessel. The docking operation is a frequent necessity in the efficient life of any ship, particularly of a naval vessel.

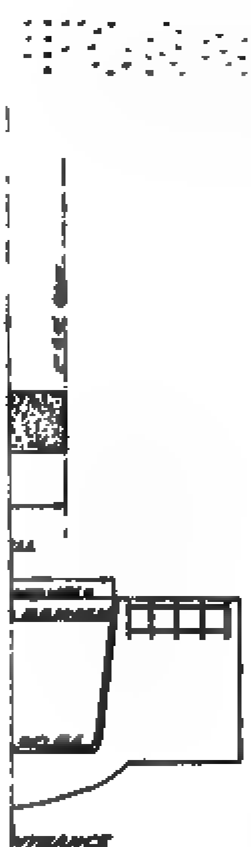
The construction of a graving dock of modern type and dimensions is no small undertaking, and calls for exacting design and close supervision by the bureau. The inception and progress of such projects

is a matter of much interest both to the department and to the engineering profession. The difficulties to be overcome are often prodigious, in spite of painstaking preliminary plans and investigations. The elements of a dry-dock problem may be summarized under the following subdivisions: (1) The body of the dock, its excavation and lining; (2) the pump well and its equipment; (3) the caisson and its seat; (4) the crane and its runway encircling the dock outside the coping; (5) the mooring devices and power-driven capstans for handling vessels into position; (6) the docking blocks, of specially selected timber, involving many thousands of board feet of material of great strength, and great care in workmanship; all the foregoing constitute engineering operations of respectable magnitude. At every stage of construction multitudinous details emerge for attention, and at any stage difficulties and dangers may arise calling for every resource of skill and experience at the disposal of those in charge. Paradoxically speaking, it is the unexpected which may be expected at all times in the construction of a dry dock.

The declaration of war by the United States found the Government already committed to a policy of expansion in the matter of dry docks, and the results accomplished since that time have been achieved in the pursuit of that program. When the question of the United States becoming a party to the war arose, and careful attention was given to American facilities available for both offensive and defensive warfare, one of the most important defects was found to be the lack of proper dry docks, both for capital ships of the Navy and for ships that would have to be taken over for transports and for the train. Quite as pressing, in peace and war, for the merchant service, was the need of docks of a huge size, made necessary by the construction of the later vessels in the transatlantic service.

The naval docking plant in 1916 consisted of 21 dry docks of all descriptions, and the Balboa dock of the Panama Canal had just been completed—the first example of the 1,000-foot class to be found in the Western Hemisphere, considered fully available for naval use as needs arise, but remotely located in relation to our coasts as a whole. Aside from the latter, the Naval Establishment could boast only one dock better than 800 feet in length, and two 740 feet long—the remaining 18 ranging below the latter figure down to 324 feet in the case of one dock built in 1834.

Congress recognized the country's deficiency in the matter of docking facilities, and by its enactments has made possible the construction, acquisition, or preferential use by the Navy of a system of five modern dry docks of proportions and equipment excelled only in one or two instances in the entire world—four of the five completed in 1919 or 1920, and one well under way toward completion during 1921. Two others, of smaller size, were finished and



Department of the Navy — Bureau of Yards & Docks

—— GENERAL PLANS ——

DRY DOCKS No. 4

U.S. NAVY YARD — NORFOLK, VA

SCALE

1 inch - 40 feet

37022—21. (To face page 288.)

added to the Naval Establishment in 1920, so that the Navy now reckons 27 graving docks of a permanent character and 2 floating docks as available for its needs, 6 of the former being capable of receiving the largest war or merchant vessels existing or contemplated at the present time. The activities of the bureau devoted to the securing of such facilities during the emergency period will be touched upon in the succeeding paragraphs.

Dry Dock No. 4, Norfolk, Va.—This was the first of the five major docks above mentioned to be put in commission. Its construction was well begun before the declaration of war, contract having been let on November 6, 1916; and substantial completion was attained on April 1, 1919, 212 days ahead of the maturity of the contract.

Measured from the head of the dock to the side of the caisson, the usable length of this dock is 1,011 feet. Its width at the coping is 144 feet, and its depth over the keel blocks at mean high tide is 40 feet—the entire height of the walls being over 50 feet. The concrete floor was placed to a minimum thickness of 20 feet, this great mass being sufficient to overcome any hydrostatic buoyancy to which the structure as a whole might be subjected. The dock has been called the most complicated piece of mass concrete construction ever built in this country, save for its duplicate at Philadelphia, discussed elsewhere in this chapter.

Around the margin extend three lines of standard-gauge railway track, two of which carry the trucks of the 50-ton service crane, the middle track being used for yard locomotives and cars, easily cleared through the portal of the crane. By this system, any materials required may be quickly handled from shop to ship or vice versa.

The entrance caisson is of steel, and was built at the Philadelphia Navy Yard. All other features of the dock were provided under public works contracts.

Flooding is accomplished by means of a tunnel built in the south wall having numerous openings throughout the lower part of the dock—the destructive effects of a few large masses of water in motion being thus minimized.

The pumping plant consists of three Worthington centrifugal pumps, electrically driven, situated at the bottom of deep wells in the south wall of the dock, and of two smaller drainage pumps. The main centrifugals have a rated capacity of 14,400 cubic feet per minute each, and are capable, working together, of unwatering the entire dock in two and one-half hours. All pumps draw water from a suction chamber situated below the foundation of the main units. Heavy rectangular sluice gates or "valves" 8 and 9 feet high, hydraulically operated, control the flow of water in the pumping and flooding operations.

A tunnel built in the upper part of the walls accommodates electric cables, fresh and salt water lines, and compressed-air pipes, such services being provided for the proper functioning of the dock when ships are under repair.

The amount of concrete poured in the execution of the whole project was 184,000 cubic yards, and 625,000 cubic yards of earth were moved in the course of the excavations.

Foundation conditions at the site were favorable, allowing work to proceed "in the dry." Two drag-line excavators were used, part of the removed material being carried out to sea in scows and the rest being used for swamp reclamation in the yard vicinity or for the back filling of the dock walls. The sides of the excavation held at the moderate slope of 1 on 1, so that no excessive amount of earth had to be handled.

The form work involved in the placing of the concrete was of unprecedented magnitude and complexity for such a project and required careful planning and supervision. Many individual wall courses were poured continuously to a height of 28 feet. One such course was 41 feet high, and the maximum section was successfully completed when a wall form 51½ feet high and 60 feet long, containing 2,000 cubic feet of concrete, was erected and filled as a true monolith, no interruption in pouring the aggregate being permitted during the seven days required for the operation. The interior of this form was a maze of water passages, pipes, stairways, electric ducts, reinforcement, and anchor bolts, with a concrete beam system for the railroad tracks to be laid above. No form work of equivalent magnitude and complexity is recalled in connection with any dry-dock project previously undertaken by the bureau.

It is impressive to note that the keel and bilge blocking required for Dry Dock No. 4 amounted to 850,000 board feet of solid oak timber mechanically joined to the floor of the structure by the proper clamps and slides. All features of this project are now in working order, and it is a matter of record that its first ship, the U. S. S. *Wisconsin*, was docked with appropriate ceremonies 26½ months after the beginning of the excavation—an achievement unprecedented in the history of docks of comparable magnitude.

The cost of the entire project, whose construction went forward under all the difficulties of war conditions, was a little less than $5,000,000.

Dry Docks Nos. 6 and 7, Norfolk, Va.—Two docks of smaller size were built adjacent to Dry Dock No. 4 at the Norfolk yard, beginning about the middle of 1918. These were built by the Emergency Feet Corporation and paid for out of its funds, and were developed to meet the requirements of the merchant marine. They are each 471 feet long. They were constructed concurrently by

Dry Dock No. 4, Navy Yard, Norfolk, Va. U. S. S. *Wisconsin*, the first vessel docked, entering.

Dry docks at Navy Yard, Norfolk, Va., with vessels docked. Left to right: No. 3, U. S. S. *Jupiter;* No. 6, S. S. *Dio;* No. 7, S. S. *Eastern Victor;* No. 4, U. S. S. *Mount Vernon.*

Dry Dock No. 6, Navy Yard, Norfolk, Va., before first flooding ceremonial. Looking toward head end.

Dry Dock No. 7, Navy Yard, Norfolk, Va. Looking toward caisson.

the contractor for Dry Dock No. 4, and the training received by his force in the building of the latter was of value in the construction of the smaller docks.

Work on these proceeded rapidly, and they were both completed within 18 months from the beginning of excavation. Their initial flooding took place in the presence of the King and Queen of the Belgians, the Queen acting as sponsor.

Since excavation for these twin docks began seven months before the completion of Dry Dock No. 4, the unique spectacle was afforded of work proceeding simultaneously on three docks in one group.

A feature making for speed in construction and efficiency in the operation of this plant is the interconnection existing between all three docks and the pumps of No. 4, so that one pumping plant serves for the unwatering of all three.

Arrangements between the Navy and the Emergency Fleet Corporation provide for the joint use of Dry Docks Nos. 6 and 7 under such conditions as will inure to the benefit of both parties. Merchant vessels have prior claim on these docks or on equivalent docking facilities, but military considerations have preponderating weight in time of war. The latter proviso justly entitles these docks to a place in the list of those fully available for naval purposes, especially in view of their advantageous location.

Dry Dock No. 3, Philadelphia.[1]—This structure is a duplicate in all essential respects of Dry Dock No. 4 at Norfolk, and its completion will add a vital link to the strategic chain of naval docks on the Atlantic coast.

The bureau's contract for the work was let about three weeks after the declaration of war by the United States, with an original time limit of 870 days.

Conditions at the site indicated that the excavation could be accomplished by simple suction dredging, but subsequent developments made necessary the division of the whole area into a number of sheet-pile cofferdams, some of which were extremely difficult to hold, and to revise the design of the dock walls from a cellular section to one with a relieving wing base.

Construction on the project began with the contractor's dredge working behind an earth cofferdam built across the proposed dock entrance. After carrying the excavation down to about half the final depth required, the dredge was unable to make further progress, owing to the inflow of material from the sides. Investigation at this point developed the fact that a deep stratum of water-bearing sand had been reached, and that dredging in this material

[1] Engineering details of the following account have been abstracted from an article by Lieut. Commander Charles A. Lee (C. E. C.), U. S. N., in Engineering News-Record for Apr. 15, 1920, p. 748.

simply allowed the water to wash more in from the sides, thus causing the banks to recede further and further. The inflow was really equivalent to that of a river 2,000 feet wide. Further dredging under these conditions would have resulted in an area of constant depth and ever-increasing width.

The dredge was removed in the early part of 1918, and construction was discontinued for nearly a year, until revised plans could be prepared by the bureau.

The method subsequently employed was to subdivide the area into sections by means of heavy steel sheet-piling, so that excavation and construction could go forward in these compartments. The piling had to withstand severe punishment in being driven through strata of compacted sand or in striking large bowlders, many of these heavy steel members having been bent and twisted completely out of shape.

Naturally a great deal of water found its way into the sheeted compartments, and pumps were constantly employed in removing from 5,000 to 8,000 gallons of water per minute from the excavation.

In spite of all difficulties, however, the work has progressed satisfactorily under the new design. Bottom excavation was handled by two 20-ton traveling derricks operating heavy orange-peel buckets, by which material was dumped into skips placed on standard flat cars. These skips were lifted from the excavation by derricks, and the material was either spilled over the cofferdam or used for backfill as the walls were completed.

Concreting of the floor proceeded by sections 10 to 30 feet long and usually of full width. Foundations for the side walls were concreted as soon as the floor sections had set, and the side walls were poured in 50-foot lengths and four "lifts" or courses, varying in volume from 350 to 1,300 cubic yards.

The setbacks encountered in the execution of this project resulted in considerable delay and expense, but the dock and all accessories are expected to be complete and in operation by the early summer of 1921. For a description of the dry-dock cranes installed at Philadelphia, Norfolk, and elsewhere the reader is referred to the chapter on shipbuilding and repair facilities.

The total cost of Dry Dock No. 3, Philadelphia, will run to approximately $6,300,000.

Dry Dock No. 1, Pearl Harbor, Hawaii.—Perhaps the most interesting engineering construction carried over from the prewar period and continued during the war was the Pearl Harbor Dry Dock. The history of the dock up to the time reconstruction was started, in 1915, is given very completely in the paper prepared by Civil Engineer H. R. Stanford, then Chief of the Bureau of Yards and Docks, and published with discussion by other engineers in the

Dry Dock No. 3, Navy Yard, Philadelphia, Pa., under construction. View taken from cofferdam at entrance.

Dry Dock No. 1, Naval Station, Pearl Harbor, Hawaii. Interior view after first pumping, showing rock ballast before completion of floor.

Dry Dock No. 1, Naval Station, Pearl Harbor, Hawaii. View of completed structure at formal opening.

Dry Dock No. 1, Naval Station, Pearl Harbor, Hawaii. General view of interior from head end.

Transactions of the American Society of Civil Engineers, Volume LXXX, year 1916.

The present Chief of the Bureau of Yards and Docks was assigned to duty as public works officer at Pearl Harbor to take charge of the reconstruction. The original contractors, the San Francisco Bridge Co., continued the work, the actual construction being handled by the Hawaiian Dredging Co.

It having been found impracticable to construct a dry dock at this location by any of the usual methods, an entirely new and theretofore unsuggested plan was covered by the new agreement. Briefly, this consisted of dividing the 1,000-foot dock into 16 sections and constructing the shell of each section base on a floating dry dock, this shell being 152 feet long (corresponding to the width out-to-out of the finished dock floor), 60 feet wide (16 sections to the 1,000-foot dock), and 16 feet high, with the floor of the shell about 8 feet thick and sides of varying thicknesses. There were 7 steel trusses in each section, approximately 150 feet long and 14 feet deep. This shell of concrete, together with its embedded steel trusses, weighed about 7,000 tons, with a displacement of about 4,000 tons. The floating dry dock on which each section base was constructed had a lifting capacity of about 3,500 tons. As each section shell was concreted, the floating dry dock was submerged, and there was floated in over the concrete shell a steel ballast tank of outside dimensions corresponding to the length and width of the concrete base; this steel ballast tank was then bolted to the upper chord truss and brace channels along the outer perimeter of the concrete shell, canvas and rubber hose being used for packing to secure a water-tight joint. When this steel ballast tank was pumped out, the concrete base attached to the bottom of the tank was lifted and the whole towed to its location in the dock. Then, by adding water to interior compartments of the ballast tank, the section was sunk on a prepared foundation of piles covered with 1 foot of broken stone. This steel ballast tank was so designed that when pumped out it formed a steel cofferdam with interior water ballast compartments, which permitted the remaining concrete in the floor and side walls of each section to be deposited in their final location "in the dry." Following this, the bolts connecting tank and base were backed out, the water was pumped from the ballast compartments of the tank, which was raised and floated free. Certain steel doors were then removed from the inshore side to clear the tops of the concrete section side walls, and the tank was towed back to the floating dock to pick up another base section. This method applied to all sections except the first or head, where because of the side walls being on a curve, they could not be constructed inside the steel cofferdam. On the first section and on a part of the second the side

walls were constructed ashore of monolithic blocks, weighing each about 145 tons. The blocks were reinforced H-shaped shells. They were set in place by means of the station 150-ton floating derrick. The first section of floating dry-dock pontoon was launched on June 22, 1915. The steel ballast tank was launched February 12, 1916. Steel erection of section 1 of the dry dock was started in the floating dock during the last week of April, and on July 7, 1916, this first section of dock was lifted free from the floating dock and sunk in its final location the following day. On September 8, 1916, the second section was landed. On January 25, 1917, the fifth section; on July 14–17, the tenth section, and on January 3, 1918, the fifteenth section was landed.

After the fifteenth section was placed, the public works officer was detached and ordered to the Bureau of Yards and Docks as chief, with rank of rear admiral, and the public works officer at Great Lakes, Commander Geo. A. McKay (C. E. C.), U. S. N., was detached on January 26, 1918, and ordered to Pearl Harbor to continue the work. The construction at that time was about 80 per cent completed. When the sixteenth section was sunk and concreted it was necessary also to set the outer granite sill for the caisson gate before the tank could be released. This interfered in part with some of the interior steel bracing, which was cut away by acetylene torch as necessary. All of the work was performed "in the dry" inside the steel cofferdam or ballast tank, at a depth of about 40 feet below water.

After the sections were set there remained the work of concreting joints between the bases and side walls before the dock could be unwatered. This was accomplished by means of tremie concrete to seal the bottom of joints, this tremie concrete being about 6 to 8 feet thick. The joints of the side walls between sections and between the head blocks at the curve of the dock were then covered with wooden cofferdam shutters, rubber hose being used for gaskets, the joints pumped down, and concrete deposited "in the dry" to above mean low water. The joints in floor were left sealed with about 6 to 8 feet of tremie concrete until after the dock was entirely unwatered.

To keep the stresses in the dock within safe limits and to provide a factor against flotation, the earth all around the side walls was back filled before unwatering. Piles of rock ballast were also placed in the center of each section of an amount sufficient to offset the stresses from reduced weight due to the omitted 18 inches of the top of the concrete floor.

The steel cofferdam ballast tank could not be used in the construction of the pump well, which was 96 feet long by 45 feet wide, and designed to rest on piles 5½ feet below low water. The pump-well floor was 3 feet thick, while the walls varied from 5½ feet thick

Dry Dock No. 1, Naval Station, Pearl Harbor, Hawaii. Pump well before launching from floating dock.

Dry Dock No. 1, Naval Station, Pearl Harbor, Hawaii. Pump well after launching from floating dock.

Dry Dock No. 1, Naval Station, Pearl Harbor, Hawaii. Admitting water through caisson for testing pumps.

Dry Dock No. 1, Naval Station, Pearl Harbor, Hawaii. General view during construction, showing sections in place.

at base to 3 feet thick at top. There were five interior compartments for pumps. The lower 17 feet of the pump well was constructed on the floating dry dock, and on this concrete base was built a wooden cofferdam approximately 102 by 51 by 40 feet high, of 6 by 12 inch timbers. The floating dry dock was then submerged and the pump well concrete base with its wooden cofferdam, drawing about 29 feet, was floated off on September 10, 1918, and moored over its final site. It was then sunk by building up the concrete walls inside the floating cofferdam. It weighed about 8,000 tons when landed. The final settlement was obtained by admitting water and flooding the interior to below the concrete-wall level. The walls, which were then about 8 feet below water, were carried to above the high-water level and the cofferdam was removed. After final settlement was attained the interior was unwatered. There were several leaks and a few small, slightly porous areas where seepage occurred. These were all repaired against the water pressure by concentrating the leaks at small pipe inserts, which pipes were then plugged.

The caisson was seated on March 25, 1919, and pumping of the dock started on March 31. Unwatering was completed on April 10, 1919. With the removal of water load the dock rose as a monolith three-sixteenths inch, owing to the elasticity of piles and soil. The floor deflected upward one-sixteenth inch. Following this, the interior dock floor joints were completed; the upper 18 inches of concrete floor with imbedded cast-iron chains was laid; stairs, rails, keel blocks, etc., were finished; small leaks were closed; and the dock was completed.

It was anticipated that because of the many joints in walls and floor there might be considerable leakage, but the dock proved to be remarkably tight. The largest leak was in the caisson gasket at one point on the bottom. The entire leakage, including this, was less than 30 gallons per minute distributed over main points, all of which were closed without difficulty.

The pump-well machinery was installed by station labor, the contractors, the Alberger Pump Co., supplying a general superintendent.

Considerable interest was attached to the formal opening of the dock on August 21, 1919, by the Secretary of the Navy. The Governor of Hawaii declared a special holiday, and the opening was attended by about 7,000 people. The chief of the bureau accompanied Secretary Daniels to the islands. Instead of docking a ship, which would have necessitated having the dock full, with a two-hour pumping period before the bottom was exposed, it was decided to have the dock empty so that it might be viewed, and to admit water through all sluiceways. After appropriate ceremonies Mrs. Daniels pressed an electric button, which opened the three large sluice gates, which

in turn admitted the water to the dock, making a particularly spectacular sight.

The total cost of the Pearl Harbor Dock in all its stages, from 1909 to the date of completion, has been $5,064,500.

South Boston Dry Dock.—In a special act dated October 17, 1918, Congress authorized the purchase from the Commonwealth of Massachusetts by the Navy Department of a graving dock, which was at that time nearing completion, together with adjacent lands, at South Boston. This dock had been undertaken by the Commonwealth as a feature contributory to the modernization of the port, and is the largest structure of its kind in the United States, being 1,176 feet long, 149 feet wide at coping, and 43 feet in depth from mean high water to the top of keel blocks.

Its acquisition by the Navy has added a most important dock on the eastern seaboard. It was completed by the Commonwealth after its purchase by the Navy had been agreed upon, and is now in full operative condition, save for a dock crane and the completion of the runway for same, which features will be provided for under a naval appropriation already made.

This dock is of concrete construction with granite lining, and is of a type comparable in every respect to those of the most recent construction for naval purposes.

Dry Dock at Hunters Point, Calif.—The naval appropriation act for the fiscal year 1915 contained a provision authorizing the Secretary of the Navy to enter into a contract for the use by the Government of dry docks at Hunters Point, San Francisco Bay, Calif., one of which docks was to be capable of receiving the largest vessel capable of passing through the locks of the Panama Canal. The construction of such a dock was to be undertaken immediately upon the consummation of the contract as contemplated, and the dock was to be completed within 24 months thereafter. The terms of the contract were to provide for the payment of a minimum rental of $50,000 per annum to the owner by the Navy in return for docking rights, which should become paramount in times of war. Docking of vessels requiring a charge in excess of $50,000 for any one year was to be paid for by the Navy at rates not exceeding those for commercial tonnage. The contract to the above effect was to cover a period of six years from the date of completion of the dock.

Such a contract was drawn on February 24, 1916, between the Navy Department and the Union Iron Works Dry Dock Co., of San Francisco. The construction of the dry dock contemplated in the act of Congress was undertaken at once, and has been carried to a successful conclusion. Destroyers were docked therein on October 14, 1918.

This structure is of the same general type as the other maximum naval docks herein described. It is 1,005 feet long, 153 feet wide at coping, and 114 feet wide at the bottom. Its site proved especially advantageous, consisting of practically solid rock and permitting the use of a relatively thin lining of concrete within the excavation.

Summing up, the Navy has obtained during the war period or shortly thereafter, either by construction, purchase, or preferential rental, the use of five dry docks of the largest size—three on the Atlantic coast and two at points on the Pacific. Furthermore, two docks of very useful moderate size have been added to the navy yard at Norfolk for merchant use.

The strategic advantage of such an expansion needs no comment here; but it may be remarked that in the event of a future war this Government will hardly be faced with an embarrassment similar to that experienced in the recent one, when the ex-German ship *Leviathan* had to be sent across the Atlantic for docking, owing to the absence of any dock to accommodate her within the continental limits of the United States.

CHAPTER XI.

POWER PLANTS.

The power problem at navy yards throughout the emergency period has been intimately connected with the requirements of the expanded shipbuilding and industrial program, and many details of the present chapter are to be considered in relation to the chapter dealing with that program.

The power-plant section of the Bureau of Yards and Docks was charged during the war with the design and erection of new plants, the extension of existing ones, and the installation of all their distribution systems for light, heat, electric power, compressed air (high and low pressure), hydraulic power, and gas (illuminating, hydrogen, and acetylene); fire-protection systems, elevators, and electric cranes of all characters were also under the cognizance of this section. Its work was done under a civilian (Mr. L. W. Bates) as project manager, with a force of 3 aids, 5 clerical assistants, and 60 draftsmen. For strictly power-plant projects 140 public-works contracts were awarded between April 6, 1917, and November 11, 1918.

The scarcity of electrical and mechanical draftsmen available for Government work necessitated the acceptance of assistance tendered by private consulting engineers having large drafting forces in their offices. The work incident to the design of the electrical and mechanical features of the first naval training camp at Hampton Roads, Va., and later of the naval training camp at Pelham Bay Park, N. Y., was intrusted to Henry C. Meyer, jr., of New York. To Charles L. Reeder, of Baltimore, was given the design of additions and alterations to the plant at the Naval Academy at Annapolis, and Francis R. Weller, of Washington, rendered assistance in the design for the central power plants at Norfolk, Philadelphia, and New London.

Norfolk and Philadelphia.—Undoubtedly the two largest and most important projects carried out by the section were the new central power plants at the navy yards at Norfolk and Philadelphia. Even prior to the entry of the United States into the war it was realized that extensive additions to the power-generating facilities at these yards would be required in connection with shipbuilding and industrial expansions then contemplated and now realized.

The existing central power plant at Norfolk was situated in the older section of the yard, and could hardly be sufficiently enlarged to meet the new demands. A complete study, with detailed estimates, was made in order to determine whether it would not be more economical and convenient to construct an entirely new plant in that section of the yard devoted to new developments, rather than to attempt the enlargement of the old plant. The correctness of this supposition was amply proved, and recommendations were made that a new power plant be constructed, to be designed in accordance with modern practice and to contain power-generating apparatus of high efficiency, with space for future expansion. These recommendations were approved, and while the detailed design of the building structure was carried out by the shipbuilding and yard development section, the power-plant section prepared the plans and specifications for the apparatus, which required the award of 16 contracts. These contracts covered turbo-alternators of 11,250 kilovolt-amperes total capacity, reciprocating air compressors supplying 13,000 cubic feet per minute, and turbo-compressors of 16,000 cubic feet per minute. There were also included water-tube boilers of 7,200 horsepower rated capacity at an operating pressure of 200 pounds per square inch with steam at 100° F. superheat; underfeed mechanical stokers capable of operating the boilers to 300 per cent of normal rating when necessary; surface condensers for turbo-alternators and for air compressors, with accompanying circulating, condensate, and air pumps; aftercoolers for the air compressors; heaters and pumps for the yard heating system; forced and induced draft fans for the boilers; pumps for various services; switchboard, wiring, motors, and other electrical equipment; heaters, tanks, draft apparatus, meters, recorders, and other mechanical apparatus. Piping for all services was provided. A complete system for coal handling was designed, which permitted the delivery of coal from cars either to outside ground storage or into the power-plant bunkers; and the reclaiming of coal from outside storage and its delivery into the bunkers. The handling of ashes was minimized by making the boiler-room basement of sufficient height to permit standard-gauge ash cars to be run through and to receive direct dumping from the stoker ash pits.

For the Norfolk and Philadelphia power houses a design was adopted which eliminated objectionable interior columns, although it somewhat increased the cost owing to the supporting of the coal bunker and roof by the side-wall columns. The buildings were constructed with no columns within the boiler-room area. The proportion of window area was made considerably greater than is commonly employed in other works of similar character, so that the interior might be as light as possible.

General view of power plant at Philadelphia Navy Yard, showing coal and ash handling plant.

Ash-removal system at power plant, Navy Yard, Philadelphia, Pa.

View of power plant from south, Navy Yard, Norfolk, Va.

Battery of boilers in power plant at Navy Yard, Norfolk, Va

The two power-plant buildings at Norfolk and Philadelphia are exact duplicates, and were built by the same contractor; the Philadelphia building, however, was completed in advance of the one at Norfolk, owing to labor difficulties at the latter yard.

The air-compressor equipment in these plants is considerably different from that employed heretofore in bureau practice, on account of the use of both the old type of massive reciprocating compressors and the comparatively recent development of a rotary compressor driven by steam turbine. The latter is lighter in weight, occupies considerably less floor space, can be installed on structural-steel foundations, and requires less attention and maintenance than the reciprocating compressors. A further advantage is secured from the use of the turbo-compressors in that the turbines are of the mixed-pressure type. These are capable of being operated on the low-pressure exhaust steam of the reciprocating units; when a deficiency in the latter occurs, high-pressure steam is automatically admitted to the high-pressure stages to meet the load. The economy thus effected is considerable. When the reciprocating unit is not in operation, the turbo-compressor operates entirely on high-pressure steam.

The boiler equipment in each of these plants consists of twelve 600-horsepower water-tube boilers equipped with superheaters, mechanical stokers, forced and induced draft apparatus, soot blowers, balanced draft regulators, draft gauges, and automatic flue-gas analyzers and meters. The boilers are set in two rows, facing a firing aisle. As before stated, the boiler equipment is designed for operation at 300 per cent of rating when necessary, so that a maximum capacity of 21,600 horsepower is possible with the present equipment; and, since space is avaliable for the installation of four additional boilers of the same capacity, the possible maximum output with all units in operation would be 28,800 horsepower, a capacity considered adequate to meet the power demands for some years to come. Three 3,750-kilovolt-ampere turbo-alternators have been installed, with space for a future unit, which would give an electrical generating capacity of 15,000 kilovolt-amperes. These units generate 3-phase, 60-cycle energy at 2,300 volts, which is standard navy-yard practice. Two 6,500-cubic-foot-per-minute reciprocating air compressors and two 8,000-cubic-foot-per-minute turbo-compressors have been installed, which provide for a total capacity of 29,000 cubic feet of free air per minute when compressed to a pressure of 100 pounds per square inch. At Norfolk only one turbo-compressor has been installed, on account of the somewhat smaller air demand expected.

Charleston, S. C.—The navy yard at Charleston, S. C., had had no additions made to its power plant since the plant's construction, in 1907, so that the increase in yard activities beginning in 1917 necessitated considerable new equipment. The building had been so de-

signed as to provide space for future installations, so that it was possible to increase the capacity without the necessity of extending the building.

The original generating equipment consisted of two 625-kilovolt-ampere turbo-alternators and the boiler installation included four 350-horsepower boilers. Beginning early in 1917, these generator and boiler capacities were increased 100 and 50 per cent, respectively, by contracts for the installation of the following new units: One 1,250-kilovolt-ampere turbo-alternator, with 2,700-square-foot surface condenser and turbine-driven circulating and condensate pumps, with air pump; one 5,000-cubic-foot-per-minute rotary air compressor with 3,800-square-foot surface condenser, turbine-driven circulating and condensate pumps, an air pump, and an aftercooler; and two 350-horsepower water-tube boilers with superheaters, mechanical stokers, and all accessories. As at Norfolk and Philadelphia, a mixed-pressure turbine was employed to drive the new rotary compressor, and the piping from the two existing reciprocating compressors and the auxiliaries was rearranged accordingly. The increase in compressor capacity was over 200 per cent.

Portsmouth, N. H.—The power plant at the navy yard, Portsmouth, N. H., is the only one which contains direct-current generating apparatus exclusively, and when extensions were required it was found expedient to install new equipment of the same type. In order to provide for the increase of power required for shipbuilding purposes, recommendations were made for the installation of an additional generating unit and a new air compressor. These recommendations were approved by the chief of the bureau, and contracts were awarded for a 1,000-kilowatt direct-current turbo-generator and a 5,000-cubic-foot-per-minute turbo air compressor, together with their accompanying auxiliaries of surface condensers, pumps, and piping. The old equipment in the plant consisted of generating units and air compressors, all of the reciprocating type; but, in order to provide space for new apparatus, it was decided to have the new units of the rotary type, which would admit of their installation without the necessity of extending the building.

Alternating-current turbo-generators had been in use for years in the majority of the navy-yard power plants, but the new 1,000-kilowatt unit purchased for Portsmouth was the first direct-current turbo-generator of any size to be installed at any yard.

The underground salt-water suction and discharge tunnels for furnishing condensing water to the power-plant units were found to be insufficient in size to supply the increased amount of water required. New tunnels were therefore constructed of reinforced concrete, and arrangements were incorporated in the design to permit, by proper manipulation of large sluice valves at certain points, the

reversal of flow of water through the conduits. This scheme allows warm water from the condensers to flow through the intake tunnel, the action of such water being to kill and dislodge the marine growth attached to the walls of the conduit which would reduce the flow of water if allowed to accumulate.

In 1918 an additional 1,000-kilowatt direct-current turbo-generator was purchased to provide capacity for the increasing load and to replace an old 500-kilowatt reciprocating-generator set which had been completely wrecked. The new unit with its accompanying auxiliaries had not been installed when the armistice was signed.

Washington, D. C.—The power plant at the navy yard and naval gun factory at Washington, D. C., contained direct-current generators driven by vertical and horizontal steam engines. The contemplated increase in activities, together with additional areas to be served, brought up the question of a change from that system to alternating-current generation and distribution. Certain large hydraulic pumps were being purchased by the Bureau of Ordnance at that time for installation at the cartridge-case shop, and recommendations were made that two 2,300-volt, 3-phase, 60-cycle alternating-current motors be purchased to drive these pumps, and that new generating equipment placed in the power plant be of the alternating-current type to furnish energy to these motors and to all new projects in the yard requiring electrical energy. Either type of generating equipment would have required a considerable period of time to manufacture, but the decision as to the type to be employed apparently became automatic when it was learned that there were certain alternating-current generating units and other power-plant apparatus, under contract by the Treasury Department, which were available for almost immediate shipment, admirably meeting the requirements of the Washington yard. The chief of the bureau, upon being advised of this fact, made a personal call upon the Assistant Secretary of the Treasury and requested that a transfer of this equipment be made. This request was made in view of the fact that immediate war needs of the Navy should take precedence over the requirements of a project which merely provided a more economical and satisfactory method of furnishing service to Government office buildings. The Treasury Department agreed to waive its prior claim under conditions that permitted a later compliance with its own pending contract.

Specifications were then prepared covering the apparatus known to be available, and bids were received from two concerns. As only one of these bids was based on apparatus which was nearly completed in the manufacturer's shops, that proposal was accepted. By this method the equipment was obtained months in advance of the date

which would have had to be set had all apparatus been manufactured after the award of the contract.

The material obtained in this manner consisted of two 4,000-kilovolt-ampere, 2,300-volt, 3-phase, 60-cycle turbo-alternators; two jet condensers for the above-mentioned turbines, complete with air pumps and tail pumps; two 100-kilowatt, 125-volt exciters, one driven by a noncondensing steam turbine and the other by a 2,300-volt, 3-phase, 60-cycle induction motor; engine-driven underfeed mechanical stokers, with the necessary forced-draft equipment, for nine of the existing 300-horsepower Babcock & Wilcox boilers; switch gear consisting of a high-tension alternating-current structure, oil switches, alternating-current and direct-current control for existing and future generators, tie switch, feeders, and exciters; and all wire, cable, conduits, control wiring, instrument transformers, bus bars, and interconnecting apparatus necessary for the complete plant. Additional boilers were not installed at this time, but the capacity of the existing ones was largely increased by the removal of old stokers and the installation of the modern type, permitting much larger overloads being carried on the boilers. At a later date an additional 4,000-kilovolt-ampere turbo-alternator was purchased and installed, together with its condenser and other auxiliaries. Also an increase in the boiler capacity was determined upon; but, as there was no available space in the boiler room, it was necessary to extend the building to house two 1,000-horsepower boilers, which were up to this time the largest units purchased for any navy yard plant.

The compressed-air capacity of the plant was increased by the purchase and installation of two 5,000-cubic-foot-per-minute mixed-pressure turbo-compressors, with condensers, pumps, and after-coolers. The piping to these units was arranged to take exhaust steam from the vertical reciprocating engines of the old generating units, or steam at high pressure if no exhaust were available. These power-plant improvements required such an increase in river circulating water for condensing purposes that it became necessary to construct a new concrete tunnel from the quay wall to the engine room.

On account of the importance of continuity of electrical supply at this yard, it was considered desirable to make arrangements for an auxiliary electrical connection with the Government power plant serving the Capitol, Congressional Library, and Senate and House Office Buildings. Permission was obtained from the Superintendent of the Capitol for this connection, and an application for permission to install an underground conduit line through the city streets between the navy yard and the Capitol power plant was approved by the Commissioners of the District of Columbia. The characteris-

tics of the electrical energy generated by the Capitol power plant were different from that generated by the navy-yard plant, so that it was necessary to purchase frequency-changers to convert the 6,600-volt, 3-phase, 25-cycle current from the Capitol plant to 2,300-volt, 3-phase, 60-cycle current suitable for yard use. These frequency-changers were installed in a substation at the yard located some distance from the power plant, so that an accident in the plant could not affect the substation equipment. Switching arrangements were provided so that the outside supply of electrical energy could be furnished to the main switchboard in the central power plant at any time, in case of accident to any unit, or to take care of temporary abnormal power demands. Power can be transferred in either direction in case of necessity, so that it is possible for the navy yard plant to furnish energy to the Capitol plant.

Training camps, Newport, R. I.—None of the war projects of the Navy required such rapid expansion as the training camps for the enlisted personnel. The cost-plus-percentage contracts awarded in several cases of the kind permitted construction work to proceed while plans were in course of preparation, thus saving considerable time. At the naval training station, Coasters Harbor Island, Newport, R. I., it was decided to construct an entirely new power plant rather than attempt to expand the old one, which contained obsolete equipment and was located disadvantageously. A cost-plus-percentage contract was therefore awarded not only for a new power plant but also, at a later date, for a complete distributing system for light, heat, and power from the plant to the new barracks buildings, and for the lighting and heating of the various units comprising the enlarged training camp. The new power plant contained two 600-kilovolt-ampere turbo-alternators, two 125-kilovolt-ampere units brought from the old plant, three 500-horsepower water-tube boilers, and various auxiliaries, such as condensers, pumps, heaters, fans, switchboard, etc.

At the request of the Bureau of Navigation this plant was designed to burn fuel oil instead of coal in order that the enlisted personnel might be trained in handling oil-burning equipment before being assigned to ships in which such equipment was used. Storage capacity for 500,000 gallons of fuel oil was provided in the form of an underground reinforced-concrete tank located some distance from the power plant, with pipe lines to the plant and a filling line to the wharf.

During the progress of the work on this contract, it was decided to construct a camp for reserves at Cloyne Field. This site was located at such a distance from the power plant that extension of the distributing systems would not have been economical. A separate boiler plant was therefore included in the camp contract to provide steam,

and electrical energy was purchased from the local public utility company.

In 1918, when it became evident that the Newport training station would require a further enlargement to provide facilities to meet the rapidly increasing demands for training personnel, it was decided to construct another camp at Coddington Point on the mainland opposite the Coasters Harbor site. (See chapter "Training camps.") On account of the area included in this development and the relative positions of the units, three separate boiler houses were constructed with a total installed capacity of 5,000 horsepower, sectional cast-iron boilers being used for supplying low-pressure steam for the heating of buildings, and horizontal return-tubular brick-set boilers being utilized for the smaller amount of high-pressure steam required for cooling, laundry, sterilizing, and water-heating purposes. The mechanical equipment contract included the three boiler houses, boilers, heaters, tanks, pumps, piping, the complete distributing systems from the boiler houses to all barracks, and the heating system within the barracks buildings. A complete plant for refrigerating and ice-making purposes was also included in the main contract, and a separate contract was awarded for the electrical distribution system for the camp. This project was considerably curtailed after the armistice, and the changes necessitated a redesign of the distributing system and the omission from each boiler plant of a portion of its equipment.

Pelham Park, N. Y.—Another large training station was constructed at Pelham Bay Park, N. Y., the mechanical equipment of which consisted of two boiler plants and the heating system of the camp buildings, with necessary interconnecting steam mains. Electrical energy for this camp was purchased from the public utility company.

Hampton Roads, Va.—The original camp at the naval operating base, Hampton Roads, Va., required for steam-making purposes a complete boiler plant containing six 500-horsepower, water-tube boilers with mechanical stokers, forced and induced-draft fan equipment, pumps, heaters, piping, etc. The bureau purchased the main items of equipment as extras on existing contracts for boilers and stokers for other yards in order to save the time required for preparation of separate specifications and for advertising. All minor items, however, and the complete distributing system were included under a cost-plus-percentage contract in order to expedite the work. The main steam-supply line from the boiler plant was installed underground on account of its size and location; all branch lines, however, from this main to the various buildings were carried overhead on pole lines, and the condensate from the pipe lines and radiating surfaces was wasted to the sewers.

The second training camp at Hampton Roads, known as the East Camp, was started in 1918, but not completed until after the armistice. Complete plans and specifications were prepared by the bureau for the electrical and mechanical equipment. The boiler plant contains ten 400-horsepower horizontal return-tubular boilers with chimneys, pumps, heater, and piping. The heating contract, in addition to the boiler-house equipment, included the distributing system, which consists of steam supply lines carried overhead on poles to all buildings, with the return mains installed underground to return the condensate from the various buildings to the boiler plant. This was said to have been the largest vacuum-heating contract ever awarded in this country and involved an expenditure of about a million dollars. There were about 400 buildings to be supplied with steam, and an approximate idea of the magnitude of the project may be realized when it is stated that there were installed 113 miles of pipe, 400,000 square feet of radiation, 5,000 valves, and 6 miles of wood pipe-covering and trenching for the return pipes in the ground.

During 1918 the main camp at the naval operating base had also been increased, and as this required during the winter months more steam than could be furnished by the original 3,000-horsepower boiler plant, the temporary demand was met by the construction of a wood-frame boiler house containing boilers which were immediately available as excess stock from other projects. This temporary plant has a capacity of 2,800 horsepower, and it is expected that its continued operation will be unnecessary when the underground interconnecting piping has been installed between the original boiler plant and the new permanent one located in the industrial section.

The permanent boiler plant at the base is located near the center of the industrial section and contains modern equipment designed for economical operation. The present apparatus consists of four 600-horsepower water-tube boilers with mechanical stokers, chimney, forced-draft fan apparatus, heaters, pumps, and piping. The design is such that the normal capacity of 2,400 horsepower may be raised to 6,000 horsepower by operating the boilers considerably over their rating, and provisions have been made for doubling the installed capacity by the addition of four more 600-horsepower boilers facing the first row. After the award of the contract for this plant, the fifth naval district recommended that the building be increased to provide space for electrical generating equipment for furnishing electrical energy to the entire base. This proposal, however, was abandoned on account of the lack of necessary appropriations.

Torpedo station, Newport, R. I.—With the rapid expansion of the torpedo station at Newport in 1918 it was decided to construct an

Boiler plant for industrial section of Naval Operating Base, Hampton Roads, Va.

Power plant at Naval Torpedo Station, Newport, R. I.

entire new power plant rather than to attempt to enlarge the old one, which contained obsolete equipment, was located in such a position that extension would have been difficult, and was installed in a building whose utilization for manufacturing purposes was desirable.

The project was undertaken at the request of the Bureau of Ordnance, whose insistence upon the urgency of the situation led the Chief of the Bureau of Yards and Docks to obtain the Secretary's authority for the award of a cost-plus-percentage contract covering the entire work, building, equipment, coal and ash facilities, and complete distributing systems for light, heat, and power.

The main equipment of the plant now consists of two 2,500-kilovolt-ampere turbo-alternators, four 600-horsepower boilers, underfeed stokers, forced and induced draft fan equipment, condensing apparatus, switchboard, two large rotary converters, and all necessary auxiliaries. The old power plant generated direct current, but to conform to modern navy-yard practice the design of the new plant called for turbo-generators arranged for 2,300-volt, 3-phase, 60-cycle current. It was therefore necessary to purchase rotary converters to obtain the necessary direct current for the operation of old motors in the shops. New motors which have subsequently been purchased are of the alternating-current type, so that the electrical energy generated may be used without conversion. An extensive distributing system has been installed from the new power plant to the various buildings and shops. This includes direct and alternating current for light and power, steam for industrial purposes, hot water for heating, water for industrial use and for fire-fighting purposes, and compressed air at low pressure (100 pounds), intermediate pressure (1,200 pounds), and high pressure (3,500 pounds per square inch), the last being used for torpedo charging.

The new plant also required a complete coal and ash handling system. Coal is handled from barges either to ground storage or direct to the bunkers in the power house, and is also reclaimed from ground storage to the bunkers.

Submarine base, New London, Conn.—Plans were made early in 1917 for the development of the submarine base at New London, and these naturally contemplated the provision of a central power plant. It was found that there was an existing coal shed, not utilized in the new scheme of development, which had a heavy concrete floor on pile foundations and was located in an advantageous position for the required plant. A new superstructure was therefore designed for installation on the old foundation, the latter being of such size that it was found possible to add a machine-shop building. The power plant was provided with three 1,875-kilovolt-ampere turbo-generators, furnishing 3-phase, 60-cycle electrical energy at 2,300 volts, and also three 823-horsepower water-tube boilers, superheaters, oil-burn-

ing equipment, air compressors, condensers, pumps, tanks, heaters, a switchboard, and other necessary auxiliaries. This project also included the installation of large reinforced-concrete storage tanks for fuel oil required for the operation of the power-plant boilers, as well as tanks of similar character for the storage of Diesel oil, heaters, and a piping system for handling these oils between the storage tanks, the power plant, and the different piers at which the submarines are berthed.

Special high-pressure air compressors were installed for torpedo charging. These machines have a capacity of 50 cubic feet of compressed air per hour at a pressure of 3,500 pounds per square inch. A later contract included complete distributing systems for fresh water, salt water, air, fuel oil, Diesel oil, hot water, and electricity from the power plant to the various buildings, shops, and piers.

Part of the distributing system for furnishing heat to certain buildings was required well in advance of the design of the permanent system. Pipe lines for the purpose were therefore installed above ground and supported by poles.

Naval Aircraft Factory, Philadelphia.—The establishment of this factory in the Philadelphia Navy Yard and its location in the undeveloped section at a considerable distance from the new central power plant, together with the comparatively large amount of steam required by it for heating and industrial purposes led to the decision to construct an independent boiler plant to serve the needs of the project. This plant contains six water-tube boilers having a total rated capacity of 4,328 boiler horsepower. It was designed for operation at a pressure of 200 pounds per square inch with no superheat, as no prime movers are installed—the steam generated being used only for heating and process work. The boilers are equipped with underfeed stokers, forced-draft fans, and a radial brick stack, all of which adjuncts enable the equipment to be operated at 200 per cent of its rating when necessary.

The plant contains the usual auxiliaries, such as heaters, tanks, pumps, meters, etc., together with a complete coal and ash handling system, comprising overhead coal bunker, track hopper, crusher, bucket conveyer, ash cars, and conveyer for ashes discharging into an outside reinforced-concrete ash-storage tank.

Electrical energy for lighting and power requirements in the aircraft factory could not be supplied by the old central power plant of the yard, and the new power plant under construction would not be in a position to furnish such energy in time to meet the demand. Arrangements were therefore made for the construction of a 13,000-volt transmission line from the nearest high-tension feeder of the Philadelphia Electric Co., and a brick building was constructed to serve as a substation, the voltage being transformed to 2,300 for dis-

View in engine room of power plant at Submarine Base, New London, Conn., showing mechanical equipment.

Elevated and underground distributing systems, Submarine Base, New London, Conn.

tribution throughout the various buildings of the factory. Interconnection was also made to the switchboard of the central power plant, in order to provide breakdown service in the event of accident to the yard's generating apparatus. At a later date, when the new central power plant was placed in operation, the amount of energy purchased from the public utility company was gradually decreased, until all of the current required by the aircraft activities was supplied by the yard plant; but the connection with the outside source of supply was maintained as a breakdown service.

Navy yard, New York.—At this yard, additions were first made to the engine room, which necessitated no extension to the building proper, and an 800-cubic-foot-per-minute turbo air compressor was installed on a structural-steel foundation in available space. A 2,500-kilovolt-ampere turbo-alternator was placed in the space formerly occupied by a 500-kilowatt vertical generator, which was transferred elsewhere.

The turbo-compressor was designed for operation with either high-pressure steam, exhaust steam, or both high and low pressure steam at the same time. This compressor required the installation of certain auxiliaries—a 4,800-square-foot surface condenser with its accompanying circulating, condensate, and air pumps, and a 2,000-square-foot aftercooler.

The 2,500-kilovolt-ampere turbo-alternator installation required a 6,000-square-foot surface condenser with condensate and air pumps, and both units required extensive changes in the piping system.

The addition of these prime movers and the installation of new buildings in the yard required an increase in the boiler-room equipment. No additional space was available in the boiler room, and it was therefore found necessary to construct an addition to the building to contain four 600-horsepower water-tube boilers operated at a pressure of 200 pounds and equipped with underfeed stokers, overhead coal bunker, coal and ash handling equipment, forced-draft fan, flue, new stack, piping, meters, and gauges.

On account of the importance of continuity of electrical service at this yard, it was considered desirable to install an auxiliary connection with the public utility supply. A temporary substation building was constructed several hundred feet from the power plant, and two 2,500-kilovolt-ampere frequency-changers, transformers, and a switchboard were installed therein, with underground cables from the power company's plant and to the main switchboard in the yard power plant. As noted in the case of the emergency electrical connection at the Washington navy yard, the characteristics of the current generated by the outside company were different from those of the yard supply, so that frequency-changers were necessary in the

conversion of 6,600-volt, 3-phase, 25-cycle Edison current to 2,300-volt, 3-phase, 60-cycle yard current.

Naval Academy.—At the Naval Academy, Annapolis, the increase in the number of midshipmen, the extension of Bancroft Hall, and the construction of new buildings necessitated a considerable enlargement of the power plant, which furnished light, heat, and power throughout the Naval Academy reservation as well as to the hospital and Marine barracks. Additional power-plant units which were added at first did not require an extension to the building. This equipment consisted of two turbo-generators—one 750-kilowatt direct-current dynamo to furnish electrical energy to the Naval Academy proper, and one 125-kilovolt-ampere alternating-current generator to furnish additional energy to meet the increasing needs of the hospital. These generators were installed on structural-steel foundations, and were provided with jet condensers, pumps, heaters, tanks, and other auxiliaries. Considerable additions were also made to the main switchboard to provide for the increased demands.

In the boiler room only one additional 400-horsepower water-tube boiler was installed, owing to space conditions. The capacity of the old boilers was greatly increased, however, by the replacement of an old type of stoker equipment under the seven existing 400-horsepower boilers with new and modern stokers of the forced-draft underfeed type, permitting the operation of the boilers at considerable overloads. This increase in boiler output was greater than the capacity of the stack could handle, so that duplicate turbine-driven induced-draft fans were installed to augment the chimney uptake.

At a subsequent date, when additional academy buildings were to be constructed, it was found necessary to increase further the boiler capacity. This was accomplished by an extension to the boiler room and the installation of three 400-horsepower water-tube boilers with underfeed stokers, a new stack, and other auxiliaries.

All of these changes necessitated extensive changes in the piping, the addition of minor equipment, a new ash-handling system, and a considerable increase in the outside distributing systems for light, heat, and power.

Boston.—Power-plant improvements at the navy yard, Boston, Mass., consisted in general of a new generating unit of a capacity of 3,750 kilovolt amperes, with surface condenser and circulating, condensate, and air pumps; four 600-horsepower water-tube boilers with underfeed stokers capable of operating the boilers at 300 per cent of rating in case of necessity; and two 2,500-cubic-foot-per-minute and one 5,600-cubic-foot-per-minute air compressors of the reciprocating type, with condensers and auxiliary pumps. The installa-

750-kilowatt turbo-generator as installed in Naval Academy power plant, Annapolis, Md.

Reciprocating air compressor (6,500 cubic feet per minute) in power plant, Navy Yard, Norfolk, Va.

tion of the air compressors required an extension of the engine room, but all other equipment was installed within the existing building.

Minor improvements were also effected to improve the operating conditions, such as a revision of the main switchboard controlling the generating apparatus and the outgoing feeders, the installation of a steam-jet system for conveying ashes from boiler pits to an elevated tank outside the boiler room, and the provision of new coal weighers of the traveling larry type which receive coal from the overhead bunker, measure and record its weight, and discharge it into the individual hoppers located over the stokers of the several boilers.

Mare Island.—The two main navy yards on the Pacific coast—Mare Island, Calif., and Puget Sound, Wash.—as well as the naval station at Pearl Harbor, Honolulu, operate their boiler plants with fuel oil instead of coal. During the war the power-plant facilities of these yards were not increased to the same extent as those of the eastern yards.

At Mare Island a 3,750-kilovolt-ampere turbo-generator and an 8,000-cubic-foot-per-minute air compressor were installed, together with surface condensers, circulating pumps, condensate pumps, air pumps, and an aftercooler. By moving one of the old air compressors of small capacity, it was possible to install this equipment in the existing engine room. At a later date a 5,000-kilovolt-ampere turbo-generator and auxiliaries were purchased, and a 1,000-horsepower water-tube boiler was transferred from the contemplated nitrate plant at Indianhead, Md., but the actual installation of these units was not effected until after the signing of the armistice.

To increase the direct-current facilities in the plant, two old, worn-out, engine-driven current generators were removed and in their place were installed two motor-generator sets and a controlling switchboard.

Puget Sound.—The boiler capacity at the navy yard, Puget Sound, Wash., was increased by the addition of two 600-horsepower water-tube boilers with superheaters, soot blowers, and oil-burning equipment; and the engine room had added to its equipment a 3,700-kilovolt-ampere turbo-generator with surface condenser, pumps (circulating, air, and condensate), piping, heaters, and foundations.

To supplement the electrical energy as required, this yard purchases a considerable amount of current, hydraulically generated, from the public utility company at very advantageous rates.

Pearl Harbor.—New equipment which has been purchased for installation in the central power plant at the naval station, Pearl Harbor, consists of a 2,500-kilovolt-ampere turbo-generator and a 3,000-cubic-foot-per-minute reciprocating air compressor with sur-

face condensing apparatus, including circulating, condensate, and air pumps, an aftercooler, heaters, piping, foundations, etc. In the boiler room the capacity was increased by two 600-horsepower water-tube boilers with superheaters, soot blowers, and oil-burning equipment. All of the above-mentioned equipment was purchased during the war, but had not been completely installed before the armistice was signed.

New Orleans.—A new power plant was constructed at the New Orleans naval station to meet the increasing demands for light, heat, and power. A building and stack had been built several years previously for the purpose of providing an adequate central power plant, but it had never been used and contained no equipment. Apparatus was therefore purchased for this building, consisting of two 625-kilovolt-ampere turbo-generators, one 2,500 and two 500 cubic-foot-per-minute air compressors, jet condensing apparatus, aftercooler, pumps, heaters, boilers, oil-burning equipment, tanks, meters, switchboard, engine-room crane, etc. It was also found feasible to transfer four of the water-tube boilers from the old power plant, and these four were combined into two units and reinstalled.

This plant is arranged for burning fuel oil, and operates condensing with circulating water obtained from the Mississippi River. In order to avoid any interference with the levee on account of the installation of large pipes, a pump house containing motor-driven centrifugal pumps was constructed in the river. The discharge line from the pumps was carried up over the levee and thence along the ground to a reservoir adjacent to the power house, whence water is obtained for the jet condensers of the prime movers.

Pensacola.—The power plant at the naval air station, Pensacola, Fla., was modernized, increased in capacity, and converted from a direct-current generating plant containing small and inefficient apparatus to an alternating-current station with modern turbo-generators and auxiliaries. On account of the limited appropriation available for the contemplated improvements, it was thought at first that these would have to be curtailed; but investigation disclosed that there were available for transfer a 500-kilowatt turbo-generator, with surface condenser and auxiliary pumps, and a hydraulic accumulator at the navy yard, New York; a 750-kilowatt turbo-generator at the plant of the American Radiator Co., Bayonne, N. J., which was the property of the Bureau of Ordnance; and a surface condenser at the navy yard, Norfolk, Va. All of this apparatus was obtained without charge, and was transferred and installed in the central power plant at Pensacola.

Other improvements effected were the relocation of a 300 and a 600 cubic-foot-per-minute air compressor, and the installation of

Boiler installation at power plant, Navy Yard, Mare Island, Calif.

Boiler installation at power plant, Navy Yard, Puget Sound, Wash.

Turbo-alternator in power plant, Navy Yard, Puget Sound, Wash

7,500-kilovolt-ampere turbo-generator in power plant at Naval Proving Ground and Smokeless-Powder Factory, Indianhead, Md.

condensers, pumps, foundations, piping, feed-water heaters, tanks, meters, etc.

Upon approval by the Secretary of the Navy, permission was granted the local street railway company to install rotary converters at the naval station, which changed alternating current from the railway company's feeder into direct current for trolley operation, thus materially improving the street car service to the station during the morning and evening rush hours.

Indianhead, Md.—Probably no other plant required a more rapid expansion of power generating equipment on account of the war than that of the naval proving ground and powder factory at Indianhead, Md. Before the war, demands were met by three 625-kilovolt-ampere turbo-generators in the central power plant. To meet war requirements there were added in rapid succession a 1,875-kilovolt-ampere turbo-generator obtained by commandeering, the unit having been intended for the city of Richmond, Va.; a 3,750-kilovolt-ampere unit purchased from the Penn Seaboard Steel Corporation, which they were prevailed upon to release by a special arrangement negotiated through the War Industries Board; and finally a 7,500-kilovolt-ampere turbo-generator. This expansion involved an increase of over 600 per cent in generating capacity. The 7,500-kilovolt-ampere unit is the largest installed in any navy yard power plant.

It was, of course, necessary to extend the engine room, not only for the turbo-generator additions above mentioned, but also for new air compressors, operated both by steam and synchronous motor power.

All of these prime movers naturally required a large increase in the amount of steam available, and two 600-horsepower water-tube boilers with superheaters, stokers, soot blowers, and other auxiliaries, were added in an extension to the boiler room. Subsequently four 1,000-horsepower boilers were installed to replace smaller boilers, and the boiler room again had to be enlarged. Other improvements consisted of an additional cooling tower, a large spray pond for cooling the condensing water required by the larger turbines, two new radial brick chimneys, jet condensers, pumps, heaters, tanks, piping, rotary converters, exciters, and a new switchboard.

CHAPTER XII.

PUBLIC WORKS AT ORDNANCE STATIONS.

The immediate necessity accompanying a state of war is the assurance of adequate and suitable weapons. At such a time matters related to ordnance are of primary importance, both for defense and aggression. When American participation in the World War became inevitable, the Bureau of Ordnance surveyed existing establishments and took such steps toward the extension of ordnance facilities as availability of resources would permit.

The increased demand for ordnance equipment and supplies of all natures created by the enlargement of the Navy and its entry into a belligerent status, together with the arming of merchant vessels and transports, necessitated the extension of existing facilities and the construction of new buildings for the manufacture, assembly, storage, and issue of such materials. With the tremendously expanded scope of the industrial activities at ordnance stations it became necessary to construct or expand the accessory facilities, including railroad systems, water supplies, and water-front and handling facilities, and to provide housing for increased personnel.

Before the American entry into the war the Bureau of Ordnance was manufacturing guns of various sizes, torpedoes, mines, and other ordnance equipment, and had contracts for the manufacture of quantities of ammunition. In the earliest stages of the war the delivery of these supplies and equipment for assembly, storage, and issue made mandatory the most rapid possible expansion of the ordnance stations. Also, the production program outlined by the Bureau of Ordnance required the utmost speed in the construction of public works at the naval gun factory and the other manufacturing plants operated by the Navy.

Most of the ordnance stations are remotely located, because of the very nature of the activities carried on, and a large proportion of the personnel consists of trained and experienced workers. Hence the provision of housing facilities within the confines of the stations themselves, without dependence upon the surrounding regions, is essential, and it was necessary to construct additional quarters for the greatly increased number of officers and enlisted and civilian workers assigned to or procured for such duties. The state of war

necessitated the assignment of an adequate marine guard to each station, especially in view of the hazardous nature of the materials to be handled. The marine guards at ordnance stations were placed under the administrative jurisdiction of the inspectors of ordnance in charge, so that barracks for the guards were constructed or enlarged.

AMMUNITION DEPOTS.

Major ammunition depots are located in the general vicinity of the naval bases. The elements entering into the assembly of ammunition are shipped in bulk to these depots, where they are assembled and loaded and made ready for issue. Other depots provide facilities for the storage of the bulk materials and loaded or assembled ammunition.

The raw materials for the ammunition details when they are received at the ammunition depots must be stored separately and under various conditions requiring a variety of storehouses. Buildings of various characteristics are also required for loading the fuses and primers, for filling the shells, for sewing and filling the powder bags, and for other purposes connected with the assembling of ammunition. After the ammunition or ammunition parts are assembled, provision must be made for storage and issue to ships.

The major ammunition depots, at which facilities exist for the conversion of the raw materials into loaded and assembled ammunition, are located at Hingham, Mass.; Iona Island, N. Y.; Fort Mifflin, Pa.; St. Juliens Creek, Va.; Puget Sound, Wash.; Mare Island, Calif.; and Kuahua, Hawaii. In addition to these, there are minor ammunition depots which provide for the storage of the bulk materials and the storage and issue of assembled ammunition, situated at New London, Conn.; Fort Lafayette, N. Y.; Lake Denmark, N. J.; Charleston, S. C.; Olongapo, P. I.; and Cavite, P. I. There are also located within various naval stations facilities for the storage and issue of ammunition, as at New Orleans, La. Necessarily, the greatest expansion during the war occurred in the depots located on the Atlantic coast.

The considerations governing the design of buildings for like purposes were essentially identical for all depots, and the greatest possible expedition of construction was necessary. The development of standard designs for various structures was therefore considered extremely advantageous, and good results were effected along this line. Besides the buildings of standard designs, which were applicable to a number of stations, there were, of course, buildings constructed to fulfill local conditions and purposes peculiar to one station. It is believed that the tremendously augmented facilities at ammunition

depots may be best illustrated by a discussion of the two classes thus demarked.

The standard design which was applied to the greatest number of projects was that of a building for the storage of powder, shells, or fixed ammunition. The essential requirements in this case were ease of handling, protection against high temperatures, sparkless floor construction, and resistance against exterior disturbances, such as flying sparks. The designed superimposed floor loads, adopted after consultation with the Bureau of Ordnance, were 750 pounds per square foot for magazine buildings and 2,000 pounds per square foot for shell houses and fixed-ammunition storehouses.

The buildings are one story in height, owing to the comparatively large floor loads, requiring floors to be laid on the ground. In some instances pile foundations and reinforced concrete floors were necessary, but the design of the buildings above the floor level is identical in any case. A standard width of 50 feet was adopted, with a height of 14 feet from the floor to the underside of the roof framing, and the lengths vary up to 250 feet by the addition of typical interior bays. The standard construction consists of terra-cotta hollow-tile walls, stuccoed on the outside, steel columns, steel roof trusses spanning the entire width of the building, asbestos shingle roofing on wood sheathing, and steel doors opening on a loading platform which extends the full length of the building and is served by a depressed railroad track. No windows are used in this design. Two types of floors were installed in various instances to obviate the danger of sparks being struck by the wheels of the hand trucks. Either an asphalt mastic floor or a blind-nailed maple floor on sleepers, above the concrete slab was adopted toward this end, and the relative economy of the types depended upon local conditions.

It was essential that the contents of the building be protected against high temperatures caused by the heat of the sun. Induction ventilators in the roof were installed in alternate bays, and, for situations having climatic conditions equivalent to those which exist on the Atlantic coast south of Hampton Roads, a ceiling was suspended from the lower chords of the roof trusses, with vents into the air space under the roof. It has been observed that the temperature inside these buildings during the heat of the day is considerably less than that outside. A lightning-protection system was installed in connection with each building. More than 100 buildings following this standard design were constructed at various depots.

A standard magazine storehouse was developed for the storage of ammunition details and miscellaneous materials. These buildings are constructed of the same general materials as the standard magazines, but are two stories in height, because of the lighter floor loads. They are provided with elevators between the two floors and have

windows and heating and electric lighting systems, since work is to be carried on in them. Buildings of this design were constructed at four stations.

Black powder, guncotton, and other particularly hazardous materials are stored underground for reasons of protection, isolation, and equality of temperature. For such storage subsurface magazines of several sizes, but of identical constructional characteristics, were designed. The subsurface magazines have reinforced concrete walls, floors, and roofs, and are built in sidehills. A steel door affords entrance into each building, faced with concrete wing walls where necessary.

Consideration was at first given to constructing the roof of each subsurface magazine in a very heavy manner, to confine a possible explosion. It was concluded, however, that such a construction might subject surrounding property to damage from flying pieces of concrete, and that it would probably be impracticable to construct a roof strong enough to confine the explosion entirely. The roof is, therefore, covered with about 3 feet of fill, and is designed strong enough merely to support the fill and any superimposed load on the ground, on the theory that an explosion will follow the lines of least resistence and will probably blow out the door and break the roof into small parts. Subsurface magazines have been built at most of the ammunition depots.

Designs were standardized for a number of other buildings in addition to the above, and the preparation of estimates, plans, and specifications was considerably expedited thereby.

Only a portion of the work, however, which was performed at ammunition depots as a part of the war program permitted standardization. The opposite condition prevailed in connection with water-front improvements, office buildings, quarters, central power, lighting, and heating systems, railroads, etc.

The railroad systems serving several of the depots were extensively augmented by additional track, and the water approaches in certain instances were deepened and widened to allow access to larger ships, in order to permit the issue of ammunition to vessels without rehandling. New piers and other water-front improvements were also constructed to increase berthing space for ships and lighters receiving or discharging ammunition.

At ammunition depots, where immense quantities of very hazardous materials are stored, the matter of fire protection is a serious and, in fact, critical item. At the outbreak of the war several of the depots which were to be greatly expanded were almost entirely devoid of proper fire protection, and several extensive systems had to be constructed, notably at Hingham, Mass.; Lake Denmark, N. J.; Fort

Lafayette, N. Y.; St. Juliens Creek, Va.; Fort Mifflin, Pa.; and Charleston, S. C. It was usually possible to procure a fresh water supply from near-by municipal or navy-yard systems, but, in the cases of St. Juliens Creek and Charleston, salt water is used. In two instances it was necessary to develop new water supplies for fire protection.

Permanent barracks for the Marine guards were built at all of the larger depots, including Hingham, Lake Denmark, and Fort Mifflin, in pursuance of the adopted policy of designating the Marine guards at such stations as units under the administration of the commanding officer of the depot.

In addition to projects of the nature specifically mentioned, miscellaneous construction of various descriptions was necessitated by the expansion of ammunition depots occasioned by the ordnance program for the war. The funds expended on public works at such depots to keep pace with this program aggregated $11,000,000.

TORPEDO STATIONS.

In spite of the fact that the use of the torpedo by the American Navy during the war was restricted by lack of opportunity, its use by the enemy demonstrated its merits as a potent weapon.

During the years preceding the war, the Bureau of Ordnance had developed the design and details of torpedoes to a very high degree, so that at the beginning of the war plans were on hand for the placing of contracts for the manufacture of large numbers of torpedoes. This condition made necessary the provision of additional assembly, overhaul, and storage facilities.

Torpedo activities of the Navy are centered at the naval torpedo station, Newport, R. I., where the repair, overhaul, issue, and proving of torpedoes are performed and where the larger part of the reserve supply is stored. Experimental and development work and the training of torpedo officers is also carried on at Newport. The plant at this point was largely increased during the war to increase production and to provide additional facilities for the handling and storage of spare parts and reserve supplies. All of the space available on Goat Island, the main torpedo station, and on Rose Island, intended for the storage of explosives, was early filled with new structures, and it became necessary to extend the development of the station to Gould Island. Altogether, the additional construction at Newport completed or initiated during the war entailed an expenditure of over $1,500,000.

The old power plant on Goat Island was entirely inadequate for the increased demands. A new power plant was therefore built

in the industrial area, at a cost of $800,000. (See chapter "Power plants.")

Quarters for seaman gunners, with dormitory and classroom facilities, were built to care for the large classes to be trained at Newport, and barracks were constructed to provide for an increase in the marine guard.

Considerable alterations were performed in connection with the existing buildings on Goat Island. New buildings, including a boathouse and miscellaneous storage buildings, were constructed in practically every available space on the island, until the facilities there comprised a well-arranged and self-contained industrial establishment, with all facilities for the care and development of torpedoes.

The storage for war heads and other explosive materials on Rose Island was increased in proportion to the increased torpedo storage on Goat Island. The construction on Gould Island, effected at a cost of about $180,000, includes a storehouse with racks for 880 torpedoes and a corresponding number of gyros, two war-head storehouses, office space, a reinforced-concrete pier, a narrow-gauge railroad system, and water-supply and fire-protection systems. An existing house was converted for use as quarters for the Marine guard. Difficulty in the construction of the pier was presented by the fact that the shale bedrock occurred at a very shallow depth. This difficulty was overcome by placing riprap around the precast reinforced concrete piles.

It is satisfactory to note that the enlargement of the public-works facilities and the increase in ordnance personnel enabled the authorities at the torpedo station to keep ahead of the torpedo program.

At the beginning of the war the Pacific coast torpedo station, Keyport, Wash., was equipped only to store, overhaul, and effect minor repairs to torpedoes. During the war, storage facilities there were increased by the construction of an additional building, but it was not necessary to augment the other facilities.

The lessons of the early stages of the war emphasized the idea, long existent with certain ordnance officers, that it would be both economical and expedient for the Navy to have a torpedo-assembly plant which would operate in times of peace, and which could be transformed to a war basis at times when hostilities advised the immediate increase of production. Such a plant would be in a position to assemble parts which could be economically made by various manufacturers. In the summer of 1918 the Secretary of the Navy approved the project for the construction of such a plant, and a site on the Potomac River at Alexandria, Va., was selected by the Bureau of Ordnance. Steps were taken to acquire the property, and the Bureau of Yards and Docks prepared plans for the plant, in consultation with the Bureau of Ordnance, to include a 4-story

Torpedo storehouse at Naval Magazine, St. Juliens Creek, Norfolk, Va.

Typical torpedo racks and crane as designed by the Bureau.

Seaplane view of Torpedo-Assembly Plant, Alexandria, Va.

assembly building 300 by 240 feet, a 2-story storage and office building 240 by 110 feet, a timber pier and bulkhead, dredging, and other auxiliary features. The buildings are of reinforced-concrete construction of the flat-slab type, and are considered to be particularly pleasing architecturally. The floors are designed for heavy loads imposed by machines necessary to the making of air flasks and the assembly of parts.

The plant has been completed, and provides facilities for the assembly of torpedoes to meet the needs of the Navy. The total expenditure for construction at Alexandria has been about $1,300,000.

The manufacture and assembly of torpedoes require such a period of time that it is essential that a sufficient number be on hand at the beginning of hostilities to fulfill immediate needs. The Bureau of Ordnance has accordingly completed a number of torpedoes, in fulfillment of the war program, which must be stored either ashore or afloat. New torpedo storehouses were built during the war, or construction started, at New London, Conn.; Newport, R. I.; St. Juliens Creek, Va.; Hampton Roads, Va.; Charleston, S. C.; Pensacola, Fla.; Coco Solo, Canal Zone; Keyport, Wash.; and Mare Island, Calif. In addition to the new storehouses, racks for the storage of torpedoes have been installed in existing buildings at Alexandria, Va., and Kuahua, Hawaii.

The Bureau of Yards and Docks, in consultation with the Bureau of Ordnance, has designed standard torpedo storehouses, either with or without overhaul space, and standard war-head storehouses. Formerly torpedoes were stored on chocks, which practice tended toward inconvenient handling, requiring the moving of a number of torpedoes to get at those at the bottom of a stack. Standard racks have been designed, which materially increase the capacity of the storehouse and permit the handling of any one torpedo without disturbing others. Methods of transfer and stowage have been developed which minimize time and labor and which practically eliminate manhandling.

In regard to the provision of facilities for the assembly and storage of torpedoes and accessories, the Bureau of Yards and Docks has kept ahead of the requirements of the Bureau of Ordnance, so that the production program has been enabled to proceed without interference on this account. A large factor in the speed of construction is attributable to the standardization of design which has been effected.

MINE DEPOTS.

The detailed plans formulated by the Bureau of Ordnance for the North Sea barrage contemplated the manufacture and placing of about 100,000 mines, of a type especially developed by the Bureau of Ordnance for this purpose. The numerous parts of the mines were

manufactured by a number of firms, and it was decided to ship the parts abroad for assembly.

The larger part of the mines were loaded with their charges of T. N. T. at the mine-filling plant, St. Juliens Creek, Va., which was built during the early part of the war. The construction of this plant was conceived after the manufacture of parts had been started, and great speed was necessary in order that the completion of the plant should not hold up the entire project.

It was proposed to build a plant to receive, load, and ship 1,000 mine cases per day, which was an undertaking entirely without precedent in the United States. Its design was accomplished by the Bureau of Ordnance and the Bureau of Yards and Docks in consultation. It included the layout of an extensive conveyor system to handle the mines. A lump-sum contract was placed and actual work was started shortly before the 1st of November, 1917. In spite of very severe weather and labor troubles, the plant was in an operative condition in March, 1918, as soon as the facilities were needed, the project for the mine barrage not being retarded on this account. The cost of construction was about $500,000.

The group comprising the mine-filling plant consists of 22 buildings and a wharf. The type of construction in general was steel frame with galvanized metal siding, which permitted rapid erection. The conveyor system proved to be excellently planned, and the handling of over 22,000,000 pounds of T. N. T. in the loading of more than 73,000 mines was performed without mishap. The rated capacity of the plant was exceeded in operation.

Shortly after the beginning of the war, construction was started on a small mine depot adjacent to the submarine base, New London, Conn. This depot was completed in accordance with the original intention, namely, to provide for the storage of mines for planting the waters in that vicinity.

In 1918 the Bureau of Ordnance presented plans to the department for the establishment of a large mine depot on the Atlantic coast, to be used for the storage, assembling, loading, testing, and issuing of mines to meet all probable future needs. The project was approved, and the vicinity of Yorktown, Va., was chosen as the site, for military and other reasons. About 11,000 acres of land for this purpose were commandeered by presidential proclamation, under authority issued by Congress, and the preparation of plans was begun for the establishment, which was designated as the Navy Mine Depot.

There has been completed at the Navy mine depot a filling plant essentially similar to the one at St. Juliens Creek, although of a more permanent type of construction. There were also built five mine-storage buildings, each 100 feet by 500 feet, and one story in height. These buildings were made thoroughly fire resisting.

For the storage of T. N. T. 10 magazine buildings were erected at points on the reservation remote from each other. The character of the terrain facilitated segregation for the storage of explosives, each building being located in a ravine separated from other buildings by high land.

The inaccessibility of the site, which is highly advantageous from a military standpoint, was overcome industrially by the construction of a railroad system, about 10 miles in total length, making connection with the main line of the C. & O. Railroad near Lee Hall, Va., and by the construction of a pier, 2,000 feet in length, extending into the York River to a draft of 30 feet at mean low water. The railroad is carried over the pier, and sidings serve the mine-filling plant and other buildings.

The transportation difficulties have been overcome further by the construction of an 18-foot concrete road, constituting a highway from the railroad station at Lee Hall to the depot and to the village of Yorktown. It forms a continuation of a concrete road extending all the way to Newport News.

This depot was established as a war activity, but construction was just started before the cessation of hostilities. Construction was continued, however, to the entire scope originally contemplated, and the industrial facilities have been completed, together with quarters for officers and enlisted men, an office building, a heating plant, and electrical transmission lines. The development is being continued further by the construction of water-supply and sewerage systems, a dispensary, a power plant, and additional railway. The total cost of the whole development is about $2,700,000, exclusive of the cost of land.

In addition to the above facilities for the manufacture and loading of mines, storage has been provided at certain naval stations, so that loaded mines may be kept on hand ready to place immediately as needed. For this purpose a standard mine-storage building was designed, having a capacity of 1,008 mines. This building has concrete foundations and floor, steel framing, brick or tile walls, a steel-skeleton mezzanine floor, and built-up roofing on wood sheathing. The small flanged wheels on the mine anchor fit the gauge of channel tracks, which are laid on the floor and on the mezzanine, extending the length of the building, and the units are stowed in this manner. A crane extends over the adjoining railroad track, so that the mines may be carried from the cars to the tracks inside the building without manual effort.

More than 20 of these standard storage buildings, costing about $800,000, were erected at various stations.

NAVAL PROVING GROUND AND SMOKELESS POWDER FACTORY, INDIANHEAD, MD.

The activities of the Bureau of Yards and Docks at Indianhead practically began with the declaration of war, as prior thereto the public-works projects undertaken there from time to time as part of a gradual development were carried out under the cognizance of the Bureau of Ordnance. At the beginning of the war the facilities for proving guns and testing shells and armor plate had been developed to a point where only a small amount of public-works construction was needed to cope with the greatly increased demands on the actual proving and testing equipment. These demands, however, necessitated enlarged facilities for the handling and transportation of guns, shells, supplies, and equipment, and a considerable increase in housing accommodations for additional officers, enlisted men, and civilian employees.

That part of the station designated as the smokeless-powder factory had been developed to a maximum capacity of 20,000 pounds per day. Immediately following the outbreak of the war it was decided to double this capacity, and construction work was started accordingly. As preparations for actual warfare progressed, however, it appeared that the enormous requirements of the Army would absorb the total output of all private powder-manufacturing concerns, and that the Navy would have to depend upon its own facilities to supply its needs in this respect. It was therefore decided further to increase the capacity of the factory at Indianhead. Under this program there were constructed a large number of buildings to house the additional special equipment required in the various manufacturing processes, together with storehouses for raw material, buildings for drying and blending powder, extensions to the power plant, and steam, water, and electric distribution systems, and additional railroad and water-front facilities.

As practically all of the employees of the station are quartered on the Government reservation, the enlargement of the powder factory necessitated the construction of additional officers' quarters, cottages, boarding houses, and barracks, and the improvement of roads, walks, and other facilities tending to the comfort and welfare of the personnel.

Among the buildings directly related to the expansion of the powder factory were:

Four storehouses for nitrate of soda, constructed of concrete and steel, with an exterior covering of corrugated galvanized steel. These storehouses are connected in pairs by a wing in which freight cars are spotted. Each pair of build-

ings is equipped with a monorail hoist system for loading and unloading. The combined capacity is 25,000 tons.

Five cotton storehouses of construction similar to the above, but of smaller capacity.

A one-story building of steel construction for use as a laboratory.

A storehouse of concrete-and-steel construction for the storage of sulphur.

Two blending towers of brick and steel-covered frame construction.

Four solvent-recovery buildings of brick construction, each consisting of four units and each unit having its separate condenser house.

Two magazine buildings of brick construction.

One pulping and poaching house of brick and steel construction.

An ammonia-compressor building, a dehydrating house, two cotton dry houses, and three picking houses, all of concrete and brick construction.

An ether house of heavy frame construction, covered with corrugated galvanized steel.

Twenty-five powder dry houses of brick construction, 10 of which had been completed when the armistice was signed, work then being stopped on the other 15.

Most of the powder dry houses were erected on a newly acquired tract of land, which was of rough topography and heavily wooded, thus necessitating considerable clearing and grading. Approximately 2 miles of railroad had to be built to tie in this tract with the rest of the station.

Among the projects of a general character were:

Bridge over Mattawoman Creek.
Steel fence inclosing a portion of the reservations.
Machine shop.
Carpenter shop.
Public works office building.
Storehouse for Marine Corps.
Thirty-room hotel.
Three 10-room boarding houses.
Garage for seven trucks.
Annex to dispensary.
Laboratory office building.
Chemical laboratory.
Post office.
Bachelor officers' quarters.

- Group of 30 frame buildings comprising mess halls and cottages for employees.
- Extension to a development of the United States Housing Corporation, comprising 45 cottages and including roads, walks, and sewer and water facilities.
- Group of cottages as nucleus of a village for colored employees.

At the beginning of the war the station's supply of fresh water was obtained from nine artesian wells, having a combined capacity of 1,600,000 gallons per 24 hours; but with the suddenly increased requirements of the powder factory and the added personnel, including more than 2,000 building mechanics and laborers, this capacity was soon overtaxed, and at times the shortage of water presented a serious problem. To meet this situation five additional artesian wells were drilled, and a test made at their completion showed that the station's water supply had been more than doubled. Unfortunately, the completion of these wells was delayed beyond the expected date of completion, and the full benefit of the increase was not felt until near the end of the period of the station's greatest activity.

Almost from the date of the establishment of the naval proving ground the lack of rail communication had been a cause of great delay and inconvenience, the nearest railroad being about 14 miles distant, and reached by a road which was usually in such poor condition as to negative the benefit which might otherwise have accrued. This condition enforced dependence on tug and barge transportation between Indianhead and the Washington navy yard. Funds for better facilities became available only during the war. After the necessary authorization was granted a standard-gauge single-track railroad approximately 12 miles in length was constructed between the proving ground and White Plains, Md., at a cost of $850,000. It makes connection at White Plains with the Popes Creek branch on the Pennsylvania Railroad, which joins the main line at Bowie, Md., some 17 miles northeast of Washington.

While not making direct connection with Washington, this trackage has admirably fulfilled the purposes for which it was projected, namely, the avoidance of transfers of carload shipments to the Washington yard and thence to lighters for Indianhead, the elimination of delays due to congestion at railway yards, and the saving of time and expense generally.

While this railroad is a facility built, owned, and operated by the Government, its advantages have been made available to private commerce by the construction of sidings at convenient points for the handling of shipments of tobacco, pulp wood, and farm products in general.

Soda storehouses at Naval Proving Ground and Smokeless-Powder Factory, Indianhead, Md.

Blending tower at Naval Proving Ground and Smokeless-Powder Factory, Indianhead, Md.

Gun shop, Navy Yard, Washington, D. C.

The powder-factory terminal of this railroad was electrified (on the overhead system) in order to minimize the dangers incident to the emission of sparks by steam locomotives. Along with the construction of the railroad, additional locomotives, flat cars, and section cars were purchased.

Prior to the war, the water-front facilities at Indianhead consisted of a merchandise pier on the Potomac River and a small coaling pier on Mattawoman Creek. The Potomac pier and the main battery of guns are located within 100 yards of each other. This arrangement presented no difficulties until, owing to the development of long-range guns, it became necessary to fire downstream instead of across the river. This change caused firing to be directed across the pier and the railroad track thereupon, and put a stop to wharf operations at such times.

To remedy this condition, a new concrete bulkhead and timber pier were constructed about 1½ miles upstream from the old landing, together with a single-track railroad connection. Approximately 30,000 cubic yards of material was dredged from the area in front of the bulkhead to secure a depth of 24 feet below mean low water.

The railroad to the new pier was constructed with great difficulty, owing to the fact that a large portion of the line skirts the high banks along the river shore, where the character of the soil was such as to cause frequent slides during construction and after initial completion. In one instance, after this line was placed in operation, a slide from one of the upper slopes required the removal of more than 10,000 cubic yards of earth.

At the Mattawoman Creek wharf the bureau constructed a concrete and timber bulkhead and enlarged the coal storage area to a capacity of 25,000 tons.

It is estimated that the cost of the work performed at Indianhead under the cognizance of the Bureau of Yards and Docks up to the signing of the armistice was $5,000,000, and that $2,000,000 additional was subsequently expended on projects which were started there during the war.

NAVAL GUN FACTORY AND NAVY YARD, WASHINGTON, D. C.

The scope of activities at the naval gun factory was practically doubled during the war. To permit the carrying out of this increased program, old structures were extended and new industrial and storage buildings were erected at a total cost of approximately $7,000,000 expended under 55 contracts.

The land available within the former boundaries of the navy yard would not permit the expansion projected during the war, so that ad-

ditional tracts to the east and west were acquired, practically doubling the yard area.

Most of the public works executed at the naval gun factory during the war comprised shop facilities, although transportation, water-front, communication, and municipal improvements were performed to supplement the industrial expansion.

At the beginning of the war this establishment was supplying the larger proportion of the guns for the Navy, and was working at maximum capacity. This function was continued without break, and the very earliest war program included extensions of buildings and facilities to enable the gun factory to fulfill the greatly increased demands made upon its resources. Plans were prepared and work was begun without delay on the following projects: An immense gun shop capable of assembling and machining naval guns of the greatest caliber; a brass foundry; a steel foundry; a forge shop; a pattern shop; an optical shop with its range-finder testing tower; and a five-story machine shop for miscellaneous work.

From an engineering standpoint, one of the most interesting of the shop buildings constructed by the bureau during the war is the new gun shop. This structure and its crane equipment are laid out with a view to the economical and efficient manufacture and handling of 20-inch 50-caliber guns.

Its width, 241 feet, was determined by the length of the lathes required for turning and boring the guns, the lathes being installed crosswise in the building. The height (to the bottom chords of the roof trusses) and width of the two main aisles, 61½ and 86 feet, respectively, were determined by the clearances needed for handling guns over the lathes and by crane dimensions and clearances. The length of the building is 567 feet.

The two main aisles are equipped with overhead traveling bridge cranes of unprecedented capacity, namely, 300 gross tons each, with a 40-foot lift. This capacity is based on the weight of a 20-inch 50-caliber gun, including its jacket and trunnions. Each crane is provided with an auxiliary trolley and hoist for handling smaller loads.

For 168 feet at one end of the main aisle the roof trusses are raised to a height of 121½ feet above the floor, and an additional 300-gross-ton crane, with a lift of 100 feet above the floor, is provided. This great height and lift are provided in order that the maximum gun may be handled in a vertical position in and out of the shrinkage pit, which is located in this aisle. On account of its unusual height, a small electric passenger elevator is provided for access to this high crane runway.

The low portion of one of the main aisles is equipped with 10-ton and the 36-foot north aisle with 25-ton traveling cranes. One main aisle is provided with a 40-ton crane, operating on the 300-ton crane

runway, for economical handling of smaller loads. Offices, tool rooms, and toilet and locker rooms are provided in the 31-foot south aisle. A storage yard 65 feet wide, served by an 80-ton traveling crane, is placed on the north side of the building.

On account of the very heavy crane loads and lateral thrusts, due to cranes and wind, it was necessary that especial care be taken and the most accurate practicable methods used in designing the structural steel framework and bracing of this shop. (See Bulletin No. 29, Public Works of the Navy, for a full engineering discussion of this and similar problems.)

The shrinkage pit mentioned above is in itself an extremely interesting engineering work. This pit, 35 feet by 68 feet in inside horizontal dimensions, with walls 5 feet thick and having an inside depth of 95 feet, was sunk by the open-caisson method. The walls were constructed in successive lifts above the floor level and the structure was gradually let into the ground at a rate keeping pace with the addition of lifts by excavating the earth inside and under the cutting edges.

Owing to the imperviousness of the soil at the site, which is a very hard clay, little water was encountered and no difficulty was experienced in keeping the bottom dry enough, by comparatively little pumping, for economical sinking. The only difficulty of note in the entire operation was that due to encountering layers of bowlders, in which cases the sinking was aided by blasting. Upon final placement of the caisson the bottom was sealed with a heavy slab of reinforced concrete.

The inside of the pit is divided into 15 vertical compartments. Six of these, 12½ feet square, are open throughout their entire depth, and it is in these that the casings are shrunk on the guns. The other compartments contain stairs, an electric passenger elevator, piping and valves, machinery, pumps, motors and shafting, etc.

A number of column foundations adjacent to the pit, placed immediately after the sinking operation, were constructed on concrete piles in order to minimize the danger of settlement.

To permit the performance of the tremendous amount of tool and miscellaneous work required on the numerous parts of guns and torpedoes, a new machine shop was built in the western extension of the yard. This building is five stories in height, 500 feet long, and 160 feet wide, with a central court roofed over at the first floor. It is among the largest buildings ever constructed for such purposes. The structure is of reinforced concrete throughout and is equipped with 15-ton cranes on the first floor, where the heaviest machines are located. The crane girders are of reinforced concrete.

The foundation conditions in this part of the yard are very poor, the ground consisting of the filled bed of the historical James Creek.

A pile substructure was used, and it was necessary to straddle two large sewers which underlie the side and could not be diverted.

Wood-block floors were laid throughout the machine shop to the extent of 36,000 square yards. This type of floor has been found to serve its purpose here in a very satisfactory manner.

Before the war the steel and brass founding were carried on in a general foundry building. In the early part of the war a separate brass foundry was built, and the general foundry building was extended for use in steel founding alone.

The new brass foundry is one story in height, with a two-story clear height in the main aisle, and is of steel-frame construction throughout. The length is 340 feet and the over-all width is about 145 feet, including a lean-to containing rooms for locker, storage, pattern, and office purposes. The building contains complete modern equipment, including crucible furnaces and core ovens. A large molding and casting floor is provided, consisting of 4 inches of molding sand on a clay base.

A separate building, 170 by 33 feet, is provided for cleaning and finishing castings. It is of the same type of construction as the brass foundry. Extensive bins for the separate storage of the several kinds of foundry sand are provided.

The extension to the general foundry is about 200 by 139 feet in plan and one story in height, with a two-story clear height in the central aisle. This building is of steel-frame construction, with steel sash, brick walls, and sandstone trimmings.

In order to provide proportionate facilities auxiliary to the new foundries, a pattern and joiner shop was built, which is four stories in height, 321 feet long, and 137 feet wide, with a central court. The construction is of reinforced concrete of the flat-slab type, with steel sash and brick curtain walls. The columns are hollow, and a system of forced ventilation is carried up inside them. A blower system is installed for the removal of sawdust and shavings. This shop is adjacent to the machine shop and has pile foundations.

Passenger and freight elevators are provided in both the pattern and machine shops. The freight elevators in the former have platforms about 20 feet square for the handling of large patterns.

Practically all the optical work for the Navy is carried on in the Washington yard. The facilities for the manufacture, repair, and testing of optical instruments were augmented by the construction of the optical shop and range-finder testing tower in the eastern extension to the yard. A notable feature of the tower mentioned is the fact that, although it forms a part of the optical shop, it is constructed with foundations and framing entirely separate from the latter in order to minimize vibrations, which would militate against accuracy in testing.

Machine shop, Navy Yard, Washington, D. C.

Pattern shop, Navy Yard, Washington, D. C.

Other buildings for various purposes were erected during the war, or completed thereafter, to take care of the expansion of the ordnance program. Such buildings include extensions to the forge shop, sight shop, erecting shop, and broadside-mount shop, besides a new model-storage building, a proof shop, lumber-storage sheds, a mine-laboratory building, and a dry kiln.

The old power plant and boiler house was enlarged to a considerable extent, and two new brick chimneys, 250 feet high, were built to take care of the increased boiler capacity. (See chapter "Power plants.")

Immense weights are handled throughout the yard, including assembled guns, mounts, and parts, and a number of outside cranes were built during the war. The heaviest of these has a capacity of 200 gross tons, with an 80-ton auxiliary, and serves the park where finished guns are stored. This is the largest outside crane of the traveling-bridge type at any naval establishment. It has a span of 85 feet and a maximum hoist of 31 feet, with a travel of 740 feet. It weighs 526,000 pounds and transmits a maximum wheel load of 89,000 pounds. Its heavy steel runway is supported by concrete foundations on piles. At one end the crane travels over a slip, so that guns may be loaded on barges for shipment to the naval proving ground.

A brick building containing complete living and classroom facilities was erected for the large classes of seaman gunners who are trained at the Washington Yard.

Auxiliary to the increased industrial facilities at the naval gun factory, miscellaneous accessory items were constructed or extended, including additional railroad, paving, a quay wall, electric ducts, sewers, fuel-oil storage, storehouses, a garage, etc.

New structures were built at the naval magazine, Bellevue, D. C., to provide facilities auxiliary to those at the navy yard for the storage of gun mounts and the like. The naval magazine was further improved by the construction of a fuse and primer-loading house, a central boiler plant, a fire-protection system, a fence, and a pier.

The war expansion has placed the Washington navy yard and naval gun factory among the largest establishments of the kind in the world, and the improvements proceeded at all times with such rapidity as to permit the fulfillment of its accelerated demands.

CHAPTER XIII.

ARMOR AND PROJECTILE PLANTS, CHARLESTON, W. VA.

After many years of controversy and discussion as to the making of battleship armor by the Government, Congress, in August, 1916, made an appropriation for the establishment of a Government armor plant. Steps were taken early in 1917 to establish this plant, when the entry of the United States into the war caused a postponement of the undertaking. The project was resumed during the middle of 1918, after a great gun-forging plant had been added to the enterprise.

The first important decision to be made in regard to the armor plant was its location. The Secretary of the Navy notified the cities of the country to submit briefs giving their advantages for the location of such a plant. The result was gratifying, as over 200 cities responded. They presented a mass of data demanding most careful consideration. The department therefore appointed a board of officers known as the armor-plant board, consisting of Rear Admiral F. F. Fletcher, U. S. N.; Commander (now Captain) F. H. Clark, U. S. N.; and Commander (now Captain) R. E. Bakenhus (C. E. C.), U. S. N. The board found it necessary to visit 25 of the cities which had presented data. A truly remarkable spirit was exhibited by the various communities under consideration. It led them to study their own resources and advantages and set them forth as had never been done before. Volumes of information were made available, showing the great extent of undeveloped resources in the United States. The board carefully weighed the labor conditions and tabulated the technical data as to freight rates, cost of fuel, pig iron, and other commodities entering into the manufacture of armor, and finally recommended that the armor plant be placed in the Pittsburgh district, and also called attention to the advantages of placing such a plant near Washington, D. C. The law, however, required that the armor plant be built within a safety zone, to be determined by the General Board. The safety zone excluded Pittsburgh, as being within 200 miles of the Great Lakes. The board having recommended Charleston, W. Va., as the most suitable place within the safety zone, the department announced the selection of that place.

In the meantime, in preparation for the impending entry into the war, Congress had appropriated the sum of $2,080,956 for the estab-

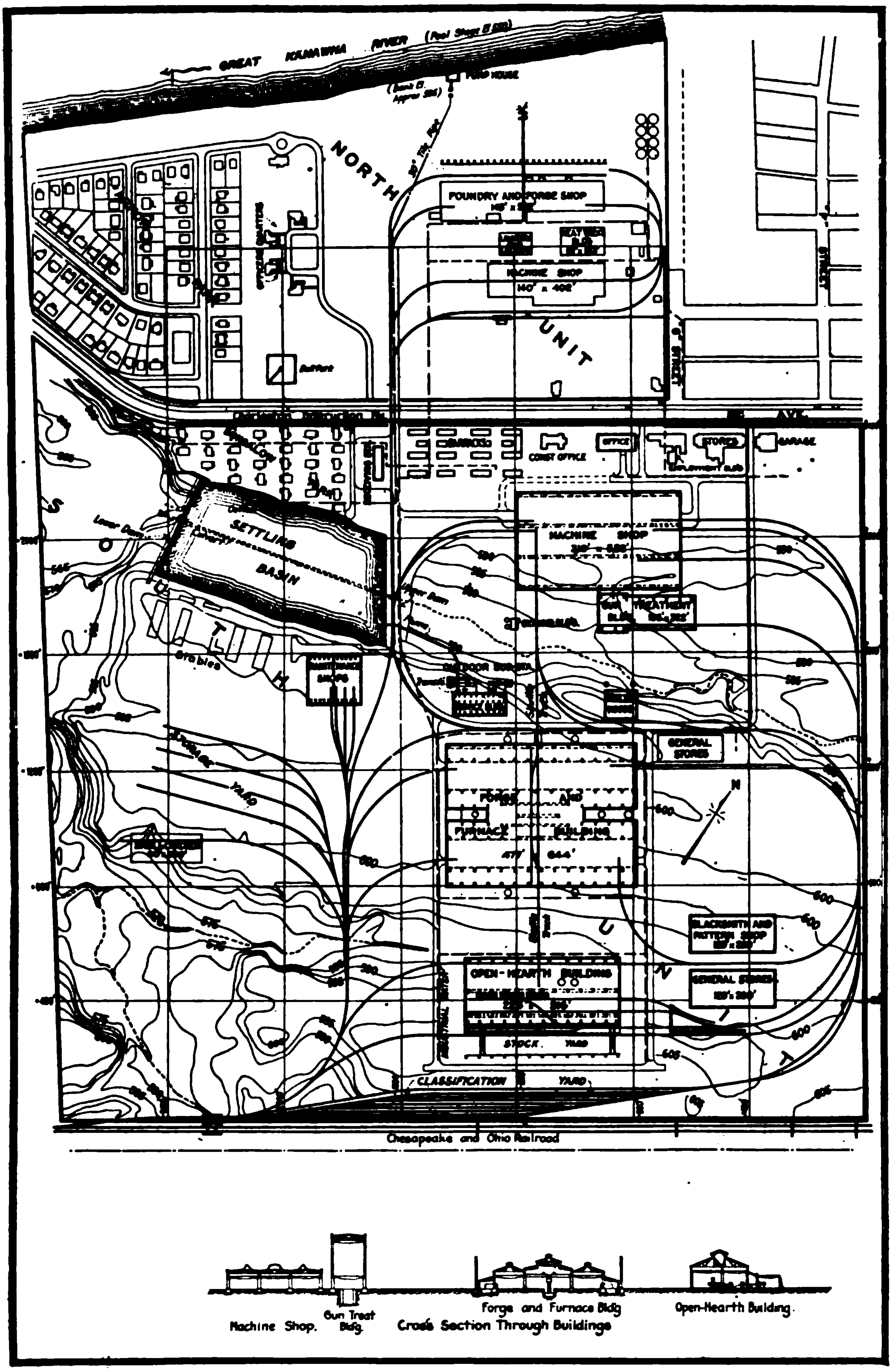
lishment of a projectile plant. On account of the close relation between the manufacture of projectiles and armor it was decided to construct the projectile plant on the armor-plant site at Charleston. About one million dollars of the funds were allotted to the Bureau of Yards and Docks for the design and construction of the plant, exclusive of machinery and furnaces, which were provided by the Bureau of Ordnance. The plant was designed under close cooperation between the two bureaus involved. Capt. R. E. Bakenhus (C. E. C.), U. S. N., was designated as project manager of the armor and projectile plants in addition to his duties as assistant manager of the Division of Shipyard Plants of the Emergency Fleet Corporation and later as Assistant Chief of the Bureau of Yards and Docks. Mr. Roger M. Freeman was appointed assistant project manager and had detailed charge of the designs.

The foundry and forge shop is a building 138 feet long by 565 feet wide, the machine shop is 140 feet long by 400 feet wide, and the heat-treatment building is 92 feet long by 153 feet wide. In the foundry and forge building particular attention was paid to lighting and ventilating, with distinct success. The monitors, with inclined sash, are of a new type, affording a greater percentage of daylight in the middle of the building than is obtainable with the ordinary arrangement. The ventilation is excellent, and the smoke which comes from the electric furnaces during certain periods of their operation rises directly and passes out through the monitors, keeping the air in the shop fresh and clear. The walls of the building are constructed of a new type of tile particularly designed to avoid expensive plastering on both the outside and the inside of the building and yet maintain a perfectly dry wall.

The projectile plant is located directly on the banks of the Great Kanawha River, on the smaller of the two tracts into which the armor-plant site is divided. The larger site, immediately adjoining the Chesapeake & Ohio Railroad, was reserved for the armor plant. The whole site comprised over 200 acres and was donated by the citizens of Charleston.

During the summer of 1918 the bureaus received instructions from the Secretary of the Navy to proceed with the construction of the armor plant. A total sum of $8,318,600 was allotted to the Bureau of Yards and Docks for the purpose of constructing the plant, exclusive of the open-hearth furnaces, heat-treatment furnaces, machine tools, and other similar manufacturing equipment, which were provided by the Bureau of Ordnance.

The well-organized personnel of the Bureau of Yards and Docks was made available for development of the project, with additions such as were found necessary during the course of the work. The plans were developed by the Bureau of Yards and Docks in close



Plot plan of Naval Armor and Projectile Plants, Charleston, W. Va.
[Reproduced by permission of American Society of Mechanical Engineers.]

Machine shop at Projectile Plant, Charleston, W. Va.

Projectile Plant, Charleston, W. Va. General view.

cooperation with the Bureau of Ordnance, Rear Admiral Ralph Earle, U. S. N., chief of bureau; Commander Logan Cresap, U. S. N., in charge of armor desk; and Rear Admiral C. B. McVay, jr., chief of bureau since June 19, 1920. The problem presented unusual difficulties. An inspection of the three existing American armor plants at Pittsburgh, Midvale, and South Bethlehem indicated at once that none of them could be used as a model or precedent. These plants had all been developed as a part of larger steel-manufacturing establishments, and the arrangements were in many cases undesirable. Plans of foreign plants, including those of the Krupp Co. and the plant at Ansaldo, were carefully studied, but could not be followed. It was therefore necessary to make entirely original studies. Unfortunately the site was intersected by two rather deep gulleys, which made a free development impracticable. However, the gulleys were utilized in part as a site for a sedimentation and storage reservoir and in part as disposal areas for waste materials which will result from the operation of the plant. Features originally disadvantageous were thus turned to good account.

During the progress of the war it developed that the great-gun manufacturing capacity of this country was insufficient for providing the Navy's needs, and it was therefore decided to add to the armor-plant facilities for the manufacture of large-caliber naval guns. This further complicated the problem. The manufacture of armor and guns consists of several principal divisions, which differ somewhat for the armor and guns, as follows:

(*a*) The manufacture of steel in the open-hearth electric furnaces for both armor and guns.
(*b*) Forging of ingots for both armor and guns.
(*c*) Heat treatment for armor and guns.
(*d*) Carbonizing and and special heat treatment for armor plate.
(*e*) Vertical heat treatment of guns.
(*f*) Heavy machine tool work for armor plate.
(*g*) Heavy lathe and machine tool work for guns.

The armor plant will turn out completed armor plate and bolts ready for installation on board ships, but for the guns will turn out only the rough forgings, the finishing work being done at the Washington Navy Yard, as has been done in the past.

A thorough analysis of the process of manufacturing armor plate and guns was made by the bureau to the extent necessary for making the layout of the plant and the designs of the buildings. It soon developed that transportation of the great masses of armor steel from the open-hearth building to the heating furnaces, thence to the forging press, back to the furnaces, then to the straightening press, then to

the carbonizing furnaces, the quenching tanks, and machine shop, formed one of the principal problems. With the guns, the masses of steel are longer and more difficult to handle, but the transfers are not so numerous. Obviously the plant should be so arranged that the transportation and handling of these enormous weights could be done with the least expenditure of time and power. Many studies were made of the relative arrangements of the furnaces and the heavy forging presses. It has been customary in other plants to have the forging presses in one building and the heat-treating furnaces in another building, and the original layout for the present armor plant contemplated such an arrangement. The studies made led to the adoption of a plan wherein the presses are in the center of a building in an H shape and the furnaces are in the two sides of the H. The general layout of the plant is shown on the accompanying drawings.

Further to facilitate transportation a "backbone" track has been provided, leading in a straight line from the open-hearth building through the foundry and forge building to the machine shop. The bulk of the weights can thus be transferred without recourse to the railroad system of the yard. Each of the buildings is equipped with giant cranes for handling the materials within the building. These are conveniently listed in the following table:

	Open hearth building.					Forage and furnace building.	
Crane number	1	2	3	4	5,6	7,8	9,10
Location	O. H. pouring slide.	O. H. pouring slide.	O. H. pouring slide.	O. H. pouring slide.	Stock yard.	Main aisle.	Main aisle.
Capacity (net tons):							
Main hoist	250	125	75	25	15	200	100
Auxiliary hoist	40	25	15	10	None.	25	25
Speed (feet per minute):							
Main hoist	10	10	14	23	50	8	10
Auxiliary hoist	20	23	30	30	0	23	23
Bridge	200	200	200	250	300	200	200
Trolley	75	75	100	150	150	75	100

	Forge and furnace building.			Machine shop.		Heat treatment building.	
Crane number	11,12	13,14	15	16,17	18,19,20,21	22	23,24
Location	Press room.		Press roo m.				
Capacity (net tons):							
Main hoist	250	....	75	150	75	75	75
Auxiliary hoist	25	....	15	25	15	None.	15
Speed (feet per minute):							
Main hoist	7	....	14	10	14	Hoist 53 lower 100	14
Auxiliary hoist	30	....	30	23	30	0	30
Bridge	150	....	200	200	200	100	200
Trolley	50	....	70	100	100	50	100

Pouring aisle in open-hearth building, Armor Plant, Charleston, W. Va.

Charging floor of open-hearth building, Armor Plant, Charleston, W. Va.

Administration building, Armor and Projectile Plants, Charleston, W. Va.

North aisle of forge and furnace building, Armor Plant, Charleston, W. Va.

It will be noted that the hot-metal cranes in the open-hearth building on the pouring side have capacities from 75 tons to 250 tons. In the machine shop and furnace building the cranes have a capacity of 100 tons to 200 tons, and in the press room of 250 tons. In the machine shop the capacities are not as great, as the ingots are reduced in weight before reaching the finishing stage, the maximum capacity of cranes there being 150 tons.

The open-hearth plant is of the most modern design, and compares favorably with the recent plants at the best steel mills. The weights to be handled are, in general, greater than at the majority of the steel plants. Two 60-ton open-hearth furnaces are provided, and two electric furnaces of 30-tons capacity each. By loading all furnaces to their maximum capacity, about 250 tons of molten steel may be had for one pouring. There is space for the addition of a third 60-ton open-hearth furnace. The stockyard immediately adjoins the open-hearth building and has two overhead traveling bridge cranes, equipped with magnets, for handling pig iron and scrap. The plant will utilize the scrap metal from all of the eastern navy yards. The tracks on the charging side of the furnace are so arranged that a train of cars containing a complete charge can be handled on the floor. The stock bins for nickel, ferrochrome, manganese, and the fluxes are beneath the charging floor in convenient locations. A low-type charging machine is provided. The open-hearth furnaces are at present supplied with natural gas, which it is estimated may last for 10 to 15 years. Provisions have been made so that gas producers or powdered-coal installation may be provided when the gas gives out.

In the ordinary processes the steel will first be melted in the open-hearth furnaces and then will be refined and further treated in the electric furnaces. One open-hearth charge is sufficient to charge both electric furnaces. The ingot is poured into cast-iron molds in the casting pit. When the ingot is solidified and cooled the cast-iron mold is stripped off and the ingot transferred to the preheating furnaces for the forging process. The crop of the ingot, that is, the top where the poorer quality of metal collects, is cut off and the ingot is then rough-forged to its approximate shape. After a further heating and reforging the ignot is sent to the carbonizing furnaces, where carbon is absorbed by the outer surface of the metal in a process requiring from 16 to 20 days. The plate is then chilled to harden it.

The forge and furnace building contains one 14,000-ton press, operated hydraulically, but of the steam-intensifier type; and one 6,500-ton press. There are three ingot-heating furnaces, eight armor plate heat-treatment furnaces, five armor plate carbonizing furnaces, three annealing, two hardening, one rectifying, and three

reforging furnaces for armor plate, all interchangeable to a certain extent. For guns there are two annealing and four heating furnaces. The vertical gun-treatment furnaces in the heat-treatment building are additional.

The forge and furnace building has two main aisles, each with a crane span of 100 feet. This is more than that provided in the commercial armor plants, but is done to give a more ample storage space for plates that are in process of manufacture or awaiting delivery for erection on the battleship. The furnaces are placed in lean-tos on both sides of the main aisles. There are thus four rows of furnaces. The presses are in the center part of the building, requiring a much greater head room than any part of the furnace building. In fact, the great head room required for the presses was one of the reasons for not putting them in the furnace-crane aisles.

Particular attention was paid to ventilation. The peak of the roof from the center of the building is left open, having over it a monitor with open sides and flat roof. It was at first contemplated having no monitor whatsoever, leaving only the open slot in the roof. This would undoubtedly have been successful, but was considered to be too great an innovation.

The open-hearth building is 516 feet long and 225 feet wide; on the pouring side it has an aisle 100 feet wide and 516 feet long. The sides of the building from the ground to a height of 8 feet are left open. A monitor on the roof also has open sides, resulting in very perfect ventilation and freedom from smoke or gases in the working spaces. The building is provided with an escape gallery for the crane operator in the event of severe accidents in pouring.

The machine shop has three aisles, each having a crane span of 100 feet and a length of 560 feet. The building has an over-all width of 324 feet and a length of 560 feet. It was desired to have the most perfect possible natural lighting in this building. This was accomplished by the use of monitors with inclined sides. The monitor over the center bay has lighting on both sides. The monitor in the side bays has lighting on one side only. Very careful studies were made of natural lighting, and the proportions of the monitors, the amount of glass, and their arrangement are based on these studies. The completion of the building has shown a most satisfactory light throughout, in spite of the fact that the building is over 300 by 500 feet in area.

The gun-treatment building proved to be a problem of some magnitude. The guns are treated in a vertical position in electrically heated furnaces. A quenching tank is provided for the cooling of the gun immediately after treatment. The gun must be lifted vertically above the tank and lowered into the tank. As the guns measure 90 feet or more, the total travel is approximately 219 feet.

South aisle of forge and furnace building, Armor Plant, Charleston, W. Va.

Press room, forge and furnace building, Armor Plant, Charleston, W. Va.

South aisle of machine shop, Armor Plant, Charleston, W. Va.

Main aisle of machine shop, Armor Plant, Charleston, W. Va.

The necessary crane clearances make the total height of the building, from the floor of the pit to the top, approximately 254 feet. To obviate a building of extraordinary height, it was decided to place the furnaces and quenching tank in a pit of approximately 50 feet depth. When erected, the gun-treatment building will be of monumental character and, on account of its height, it will dominate the valley of the Great Kanawha River for miles.

The bureau, in designing this plant, made particular efforts that it should have not only the maximum of usefulness with the greatest economy in construction, but that it should also be of pleasing appearance and durable in character. The plans of the engineers were all required to pass muster before the bureau's architectural committee, consisting of Commander F. W. Southworth, (C. E. C.), U. S. N. R. F., chairman, Mr. Philip Hiss, Mr. Wm. Partridge, and Mr. W. H. Fenton. The committee passed on the character of material to be used for the outer walls, as well as upon the architectural features. The result has been very gratifying, as the buildings are dignified in appearance, and pleasing to those who may have only a casual glimpse of them from the train, or to those who see them daily. The exterior walls are built of a specially designed block with air cells so arranged that moisture can not pass through. The blocks are strong and have been used in a wall of 8 inches thickness for a height of 80 feet without lateral support except from the steel frame. The exterior faces of the blocks are large, measuring about 5 by 12 inches, and have a rough exterior texture. The satisfactory architectural appearance did not involve any additional cost; in fact, the suggestions of the architectural committee actually reduced the cost to some extent due to the simplification of the designs. The practice of requiring all building designs to pass the architectural committee has been extended to all of the bureau's projects on account of the success gained at the armor and projectile plants at South Charleston.

It was decided in the late summer of 1918 to proceed with the construction work. Three courses were possible: Cost-plus contract, lump-sum contract, or day labor. Most careful thought was given this matter. The cost-plus form of contract was at the time in evil repute in the Government service as there appeared to be no way in which minimum cost could be assured. It must be remembered that at the time the rates of wages and the costs of materials were continually rising, and it would have been futile to expect to secure a contractor to prosecute the work on a lump-sum contract. The only course left open was to construct the work by direct employment of day labor. The bureau was not unmindful of the responsibility which it was undertaking to construct a plant under such unfavorable conditions, by day labor, on the basis of estimates made in

1912 and 1913, yet, based on the recommendation of the project manager, this course was recommended to the Secretary jointly by the Bureaus of Yards and Docks and Ordnance. Secretary Daniels showed his confidence in the naval organization by approving the day-labor method.

Active construction work began on the site in July, 1917. The designing force, in part, under the immediate supervision of Mr. Thomas Callahan, with Mr. Freeman in charge, were transferred gradually to Charleston to direct the construction work. Almost insurmountable difficulties presented themselves due to shortage of labor. There was almost no local labor and no vacant housing for imported labor. Barracks were therefore first constructed with messing arrangements, and labor was then brought in from distant points. There was a heavy turnover.

Salvage construction plant and building material were secured from the Erie Forge Plant, from the new Navy Building in Washington, and elsewhere. The armistice came while the work was in progress. This brought with it the opportunity to secure further salvage material from other points. These materials as well as plant were utilized to the greatest possible extent. Contracts were let for 50,000,000 pounds of steel framework, the gypsum of nearly 20 acres in area, the steel sash 267,000 square feet in area, and the roof covering of about 20 acres, but the excavating, the concrete foundations, the building walls and floors, the railroad track system, and the distributing systems were done by day labor.

The power problem was one of the most serious of all. Little data could be obtained upon which to base designs, and draftsmen and engineers could not be had in sufficient numbers to make the designs. The power-plant work was in charge of Mr. H. M. Cogan, electrical and mechanical engineer, reporting direct to the project manager. It was always the desire to have an electric generating station on the armor-plant property, but it developed after the armistice that the Army, in connection with the development at Nitro, had placed power-plant apparatus in the plant of the Virginian Power Co. at Cabin Creek, about 15 miles up the valley. This remained the property of the Army, but due to the closing of the Nitro project was of no further use to the Army. Accordingly a three-part contract was made between the Army, the Navy, and the Virginian Power Co., transferring the plant and necessary transmission lines to the Navy. While this was not so desirable as a power station on the site, it was most fortunate for the armor plant as it saved an investment of some $3,000,000 which the armor-plant appropriation could not have afforded. There are duplicate transmission lines by entirely different routes.

For operating the forging presses a complete steam boiler plant was secured from the Army powder plant at Old Hickory, Tenn.

The projectile plant was constructed by contract. Mr. F. D. Warren, supervising engineer, was the representative of the bureau at South Charleston, and was the first representative of the Navy Department on the ground for any purpose in connection with the naval ordnance plant. Work was begun in August, 1917, and substantially completed in May, 1918. The plant began operations under the direction of the Bureau of Ordnance in September, 1918, for the manufacture of 4-inch and 6-inch gun forgings, as well as air flasks for torpedoes, while Commander J. B. Rhodes, U. S. N., was inspector of ordnance in charge. Capt. George R. Marvell, U. S. N., was inspector of ordnance in charge during the principal construction work on the armor plant. Mr. W. E. Hayes has been in charge of the cold-metal division since the beginning, and his advice has been invaluable. Mr. W. J. Priestley, in charge of the hot-metal department, came to the plant in time to be of valuable service in the final features of the design.

The plant already has an order for armor for ships on the 1916 program, construction of which was delayed due to the World War. It is fortunate that the plant is ready for service, inasmuch as the capacity of the civil armor-making plants is not sufficient to supply the demand at the present time. This is true also of large-size guns. It is the policy of the department not to drive the privately owned armor plants out of business, but to use the Government-owned plant as a check on what should be reasonable prices for armor and gun forgings, to supplement the total capacity of the country, and to use the Government plant for experiments in improving the manufacture of armor and other forgings under the direct supervision of the Government.

CHAPTER XIV.

STORAGE FACILITIES.

GENERAL CONDITIONS.

Necessity for additional facilities.—As the demand for storage space, long prior to the war, exceeded that available, the need of additional facilities to provide for the storage of supplies for increased shipbuilding and general industrial activity and for a far greater number of ships was taken account of in connection with the development plans begun as a result of the preparedness program of 1916.

Type plans.—Studies of the needs of the yards were made, and type sketches for storage buildings for general supplies, lumber, steel, boats, etc., were worked up in consultation with a representative of the Bureau of Supplies and Accounts, and the plans for a typical permanent general storehouse were submitted to the various yards for comment. Certain specific appropriations for storage facilities were secured from Congress by act of March 4, 1917.

First new general storehouses.—At the outbreak of the war the enormous and immediate increase in the Navy's ships, industries, and personnel made quick action imperative. Accordingly, allotments of funds were made by the department from the naval emergency fund to supplement the comparatively small specific appropriations, and plans and specifications were prepared for large reinforced-concrete general storehouses for the industrial yards and more important stations, such as New York, Boston, Philadelphia, Mare Island, Puget Sound, New London, Hampton Roads, Charleston, Pearl Harbor, and Washington. Contracts were awarded during 1917, in the order named, for all of these buildings.

Fleet supply bases.—At the primary bases for operations on the Atlantic coast, New York and Hampton Roads, it was also necessary to provide millions of square feet of space for the storage of supplies for the fleet.

The navy yard at New York providing neither the storage space nor the requisite room for expansion, it was necessary to look elsewhere on the water front for a location for an adequate fleet supply base. The requisite site was found in South Brooklyn, and the eminently successful construction operation carried through at this

point will be discussed in some detail at another place in this chapter.

The reasons for locating the other fleet-supply base at Hampton Roads were similar to those which determined the location of the Brooklyn supply base—the Hampton Roads site was more to be preferred for operating reasons; space at the Norfolk yard was already restricted and needed for industrial purposes, and although no storage facilities were already available at Hampton Roads, the space and water front were more than ample for the immediate and future development. At this location, besides the general storehouse started in 1917, a large cold-storage and ice-manufacturing plant, various provisions for the open storage of nonperishable materials, and a large frame temporary storehouse were started or completed in 1917 and were followed in 1918 by additional large temporary storehouses and further provisions for open storage, and in 1919 by still further temporary buildings and three additional permanent storehouses—a six and a one story general storehouse and a three-story airplane storehouse.

Temporary storage facilities.—In naval appropriation and deficiency acts passed during 1917 and 1918 Congress took account of the necessity of a general fund for the provision of emergency storage by appropriating a total of $5,700,000 under the heading "Temporary storage facilities, Navy."

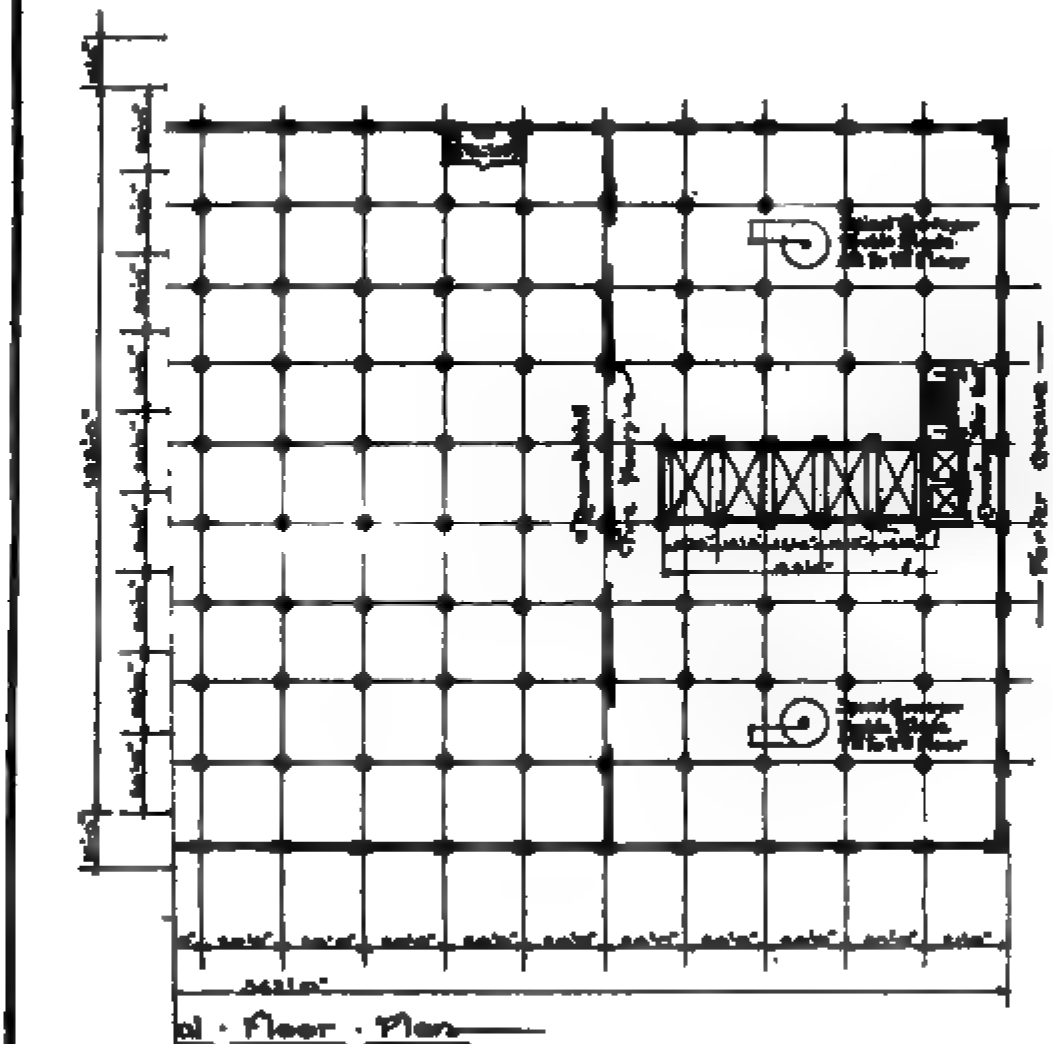
With this fund a number of large emergency timber storehouses were rapidly erected at Norfolk, Philadelphia, and New York; the development of the supply base at Hampton Roads was continued to a great extent, and a large number of storage projects of a miscellaneous character were carried out at practically all yards and stations of any importance, thus greatly ameliorating conditions but by no means affording entire relief.

General results.—Although funds in excess of $30,000,000, granted under specific and general appropriations, have been expended for storage purposes and about 30 large permanent buildings and over 100 temporary and minor structures have been erected since 1916, providing in all 15,000,000 square feet of storage area, and although considerable storage space in addition was rented at various locations and space was used in Army supply bases, it is a significant fact that the need for space is still urgent at most stations, and it is probable that practically all of the storage facilities installed merely as "temporary" or "emergency" projects will be used advantageously for many years to come.

The foregoing figures, the following list of specific appropriations for storage purposes, and this chapter generally, do not cover storage for ordnance and ammunition, fuel (except emergency coal

General storehouse, Navy Yard, Boston, Mass.

General storehouse, Navy Yard, New York, N. Y.



BUREAU OF YARDS & DOCKS · NAVY DEP'T.

· GENERAL PLANS ·

GENERAL STOREHOUSE

(BUILDING No ....)

U.S. NAVY YARD PHILADELPHIA, PA.

SCALE

1 INCH = 30 FEET

87022—21. (To face page 320.)

depots), and fuel oil, nor medical supplies, which facilities are treated under other headings.

Appropriations.—These are best presented in tabular form, as follows:

Specific appropriations for storage since 1916 (not including ordnance, fuel, and medical storage).

Date of approval of act.	Appropriation.		Subhead.		Amount.
	No.	Title.	No.	Title.	
Oct. 6, 1917	298	Temporary storage facilities.			$1,000,000.00
Mar. 28, 1918	298	.....do			500,000.00
July 1, 1918	298	.....do			1,000,000.00
Nov. 4, 1918	298	.....do			3,200,000.00
July 11, 1919	215	Navy yard, Portsmouth.	168	Lumber yard and storage	30,000.00
Mar. 4, 1917	218	Navy yard, New York.	229	Storage facilities	500,000.00
June 4, 1920	218	.....do	233	Storage facilities for gasoline and turpentine.	6,000.00
	218	.....do	236	Steel storage, etc	200,000.00
Aug. 29, 1916	219	Navy Yard, Philadelphia	200	Quartermaster's depot, Marine Corps.	175,000.00
Mar. 4, 1917	219	.....do	204	.....do	200,000.00
July 1, 1918	219	.....do	208	Depot of supplies	35,000.00
	219	.....do	209	Additional land for above	41,240.23
July 11, 1919	219	.....do	213	Pattern shop and storage	400,000.00
Aug. 29, 1916	220	Navy yard, Washington.	115	Model storage	65,000.00
July 1, 1918	221	Navy yard, Norfolk	234	Steel and lumber storage	400,000.00
June 4, 1920	221	.....do	244	Steel storage	220,000.00
July 11, 1919	221	.....do	241	Paint and oil storehouse	75,000.00
	221	.....do	242	Pattern shop and storage	400,000.00
Mar. 4, 1917	222	Navy yard, Charleston	109	Storage facilities	50,000.00
July 1, 1918	222	.....do	114	Boat storage	10,000.00
Mar. 4, 1917	227	Navy yard, Puget Sound.	220	Storage facilities	500,000.00
Mar. 4, 1917	229	Naval station, Guam	27	.....do	5,000.00
July 1, 1918	229	.....do	31	Cold storage	40,000.00
July 11, 1919	229	.....do	36	Lumber shed	5,000.00
July 1, 1918	230	Naval station, Guantanamo.	14	Storage facilities	20,000.00
Mar. 4, 1917	232	Naval station, Pearl Harbor.	63	Storehouse	100,000.00
Mar. 4, 1917	247	Marine barracks, Philadelphia.	4	Advance base storage	80,000.00
July 1, 1918	253	Naval Academy, Annapolis.	19	General storage building	100,000.00
July 1, 1918	270	Naval station, Tutuila, Samoa.	27	Storehouse	15,000.00
July 11, 1919	270	.....do	30	Lumber storage	5,000.00
June 4, 1920	274	Naval fuel depot, San Diego.	3	Storehouse and fleet landing	400,000.00
Oct. 6, 1917	292	Naval operating base, Hampton Roads.	2	Cold storage	300,000.00

Emergency fueling plants.—Particularly urgent needs during the war were those for facilities for the storage of coal at the points of troop and supply embarkation for Europe, and for facilities for the fueling of ships without a moment's delay to troops or cargo. It will be recalled in this connection that the Navy, through the Naval Overseas Transportation Service, was charged with the whole operation of transports conveying America's contribution to the western front. These storage and bunkering facilities and their effect in reducing the turnaround of transports are discussed under the heading "Emergency coal and bunkering depots."

Some of the larger storage projects are considered of sufficient general and engineering interest to warrant further description, which is given below under "Details of design and construction" and "Fleet supply bases."

DETAILS OF DESIGN AND CONSTRUCTION.

Permanent general storehouses.—In connection with its studies on the type plans for permanent general storehouses the bureau made analyses of the various types of fireproof construction, namely, (*a*) structural steel framework with reinforced-concrete floor slabs; (*b*) the reinforced-concrete column, girder, beam, and slab; and (*c*) reinforced-concrete column and flat-slab construction. The outcome was that the last-named type, as had been expected, was found to be the most desirable from the standpoints of economy, speed of construction, floor headroom, and daylighting, and (together with the second named) more desirable and economical than steel construction from the standpoint of fireproofing.

The typical new general storehouse is from 4 to 11 stories in height, and is, as implied above, of flat-slab or "mushroom" construction, with columns spaced 20 or 21 feet on centers in both directions. The four-way system of reinforcement was almost entirely used, and the design codes of the Joint Committee on Concrete and Reinforced Concrete, the Bureau of Yards and Docks, and the city of Chicago were used in various instances.

The story heights generally used were 15 feet for the first and 10 feet 6 inches for stories above, measured from floor to floor; stairways are located adjacent to outside walls of buildings in fireproof wells; elevators are also located in fireproof wells; interior fire walls with automatic fire doors and automatic sprinkler systems are provided in accordance with the best current and codified practice.

In the more recent of the large storehouses the elevators are arranged in banks for the maximum efficiency in operation and routing of supplies; the number of cars is amply proportioned to the floor areas served, and the size of car platforms, 9 by 18 feet, with two end doors of full width, adapts them to the use of storage-battery trucks or tractors and trailers. The usual live-load capacity is 5 tons per car.

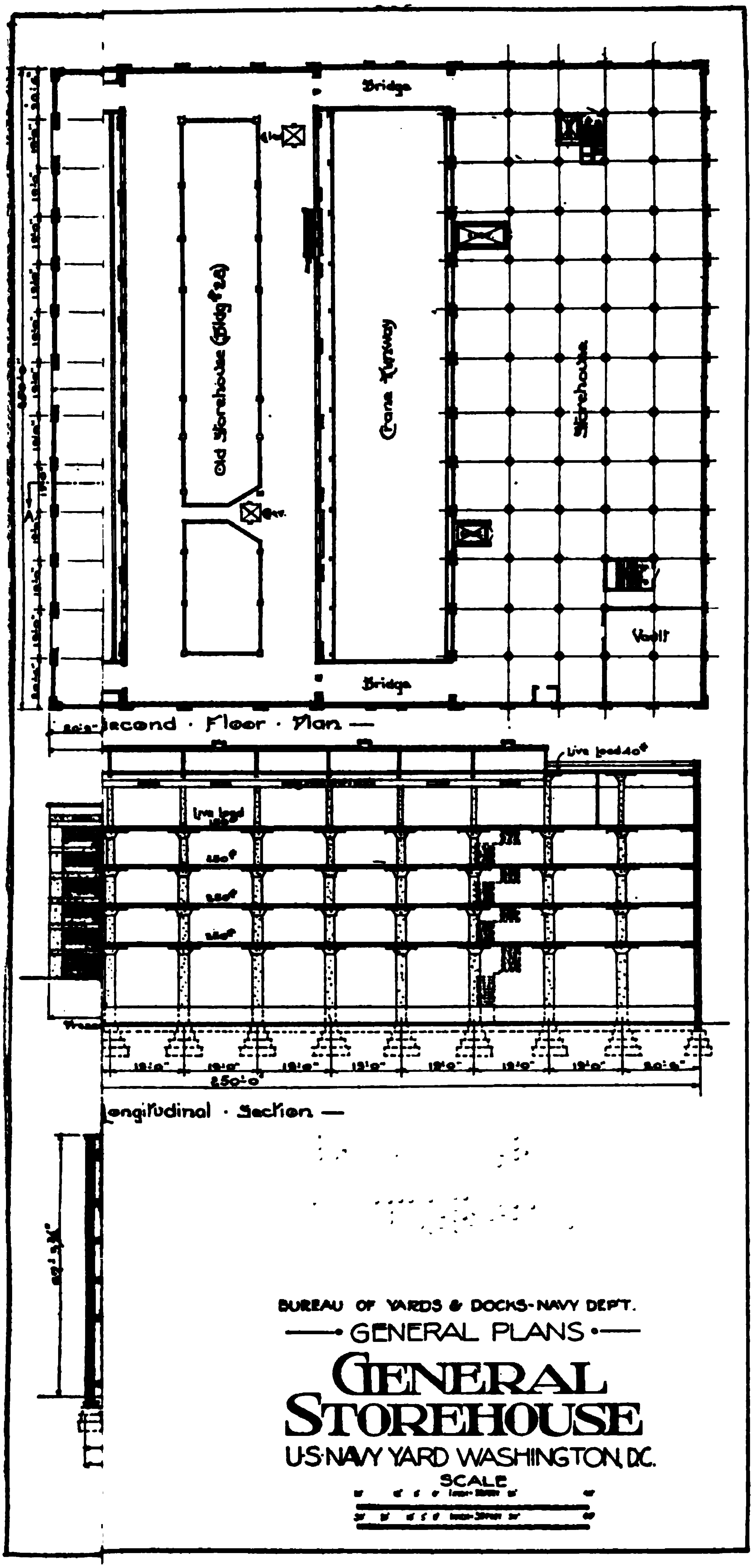
The main floors are generally about 4 feet above street level and are provided with outside platforms to permit of trucking material directly into and from railroad cars or trucks. As a further aid to "keeping goods on wheels and moving" while in transit, ramps are usually provided from street to first-floor level for the use of storage-battery trucks, etc.

Six-story general storehouses, Naval Operating Base, Hampton Roads, Va. Building 101.

Six-story general storehouses, Naval Operating Base, Hampton Roads, Va. Building 103.

General storehouse group, Navy Yard, Washington, D. C.

Interior of general storehouse, Navy Yard, Washington, D. C., showing crane service.



87022—21. (To face page 824.)

One-story general storehouse, Naval Operating Base, Hampton Roads, Va.

General storehouse, Navy Yard, Puget Sound, Wash.

General storehouse, Navy Yard, Puget Sound, Wash. Interior view, top floor.

General storehouse, Navy Yard, Puget Sound, Wash. Interior view, ground floor.

The outside faces of the buildings consist of concrete wall columns and spandrel beams, hollow brick spandrel walls, and steel sash with heavy wire glazing. Because of the heavy loads and the foundation conditions existing at practically all navy yards, these buildings have been founded on timber or concrete piles. The illustrations show typical floor plans and exteriors.

Considerable speed was made in the construction of some of these buildings, notably in the case of the large general storehouses at the New York navy yard and at the fleet supply base, South Brooklyn, both of which were constructed by the Turner Construction Co., of New York. The former building, the largest of any constructed, next to those at South Brooklyn, is 11 stories high, 180 feet wide by 360 feet long, with a floor area of 713,000 square feet, and it was completed for occupancy in six and one-half months after the contract was signed. The two large general storehouses and two warehouses at the fleet supply base, containing together 2,300,000 square feet of storage space, were made ready for occupancy in seven and one-half months.

Another type of general storehouse needed at the important yards and stations is a one-story building with suitable crane facilities for the storage and handling of heavy material, salvage material, material turned in from ships, etc. Large buildings of this type have been erected at the South Brooklyn and Hampton Roads supply bases.

The following table shows the principal permanent storehouses constructed and the more important characteristics of each:

Permanent naval storage projects executed subsequent to the "preparedness act" of August 29, 1916.

Yard or station.	Building.	Year constructed.	Width.	Length.	Number of stories.	Floor space.	Type of construction.
			Feet.	*Feet.*		*Square feet.*	
Boston	General storehouse	1917	185	265	6	252,000	Reinforced concrete (flat slab.)
Do	General storehouse addition.	1918	185	265 180	2 8	385,000	Do.
New London	General storehouse.	1917	64	224	4	57,000	Do.
New York	do	1917	180	360	11	713,000	Do.
South Brooklyn	do	1918	200	700	8	919,000	Do.
Do	do	1918	200	700	8	1,120,000	Do.
Do	Aircraft storehouse.	1917	300	383	1	115,000	Steel, brick, etc.
Do	Warehouse	1918	300	355	1	106,500	Timber, tile, etc.
Do	do	1918	355	361	1	157,000	Do.
Philadelphia	General storehouse	1917	104	424	7	307,000	Reinforced concrete (flat slab).
Do	do	1918	183	363	7	465,000	Do.
Do	Aircraft storehouse.	1918	180	200	6	216,000	
Do	do	1919	300	350	1	100,000	

Permanent naval storage projects executed subsequent to the "preparedness act" of August 29, 1916—Continued.

Yard or station.	Building.	Year constructed.	Width.	Length.	Number of stories.	Floor space.	Type of construction.
			Feet.	*Feet.*		*Square feet.*	
Washington	General storehouse extension.	1918	150	250	5	137,000	Reinforced concrete (flat slab.)
Hampton Roads	General storehouse	1917	118	495	6	350,000	Do.
Do	do	1919	118	442	6	313,000	Do.
Do	Cold storage	1918	118	263	4	92,000	Do.
Do	General storehouse	1919	170	614	1	105,000	Structural steel and tile.
Do	Aircraft storehouse.	1919	168	935	3	405,000	Do.
Charleston	General storehouse	1917	60	320	4	96,000	Reinforced concrete (flat slab).
Mare Island	do	1917	64	404	4 and basement.	128,000	Do.
Do	Electrical storehouse.	1918	84	104	5	44,000	Do.
Puget Sound	General storehouse	1917	120	240	10	288,000	Do.
Annapolis	do	1919	53	120	3	19,000	Reinforced concrete and brick.
Pearl Harbor	General storehouse extension.	1917	61	151	4	37,000	Reinforced concrete (flat slab).

Temporary storehouses.—The temporary general storehouses erected are, as a rule, of one or two stories. Timber construction was used in most cases. Concrete ground floors were used as the material of lowest cost consistent with durability and ease in trucking and handling stores. In some instances light steel buildings of a portable unit type were used.

Some of the largest of the timber buildings erected were: Hampton Roads, 2 structures, one story, 265 by 720 feet; Norfolk, 2, one story, 250 by 780 feet; Philadelphia, 3, one story, 100 by 800 feet, 90 by 800 feet, 60 by 800 feet; New York, 2, two story, 100 by 175 feet; 1, two story, 84 by 175 feet; South Brooklyn, 2, two story, 350 by 380 feet, 320 by 346 feet, etc.

In most cases these structures were very rapidly erected. For instance, the 265 by 720 foot building at Hampton Roads was constructed in 28 days from the date of authorization.

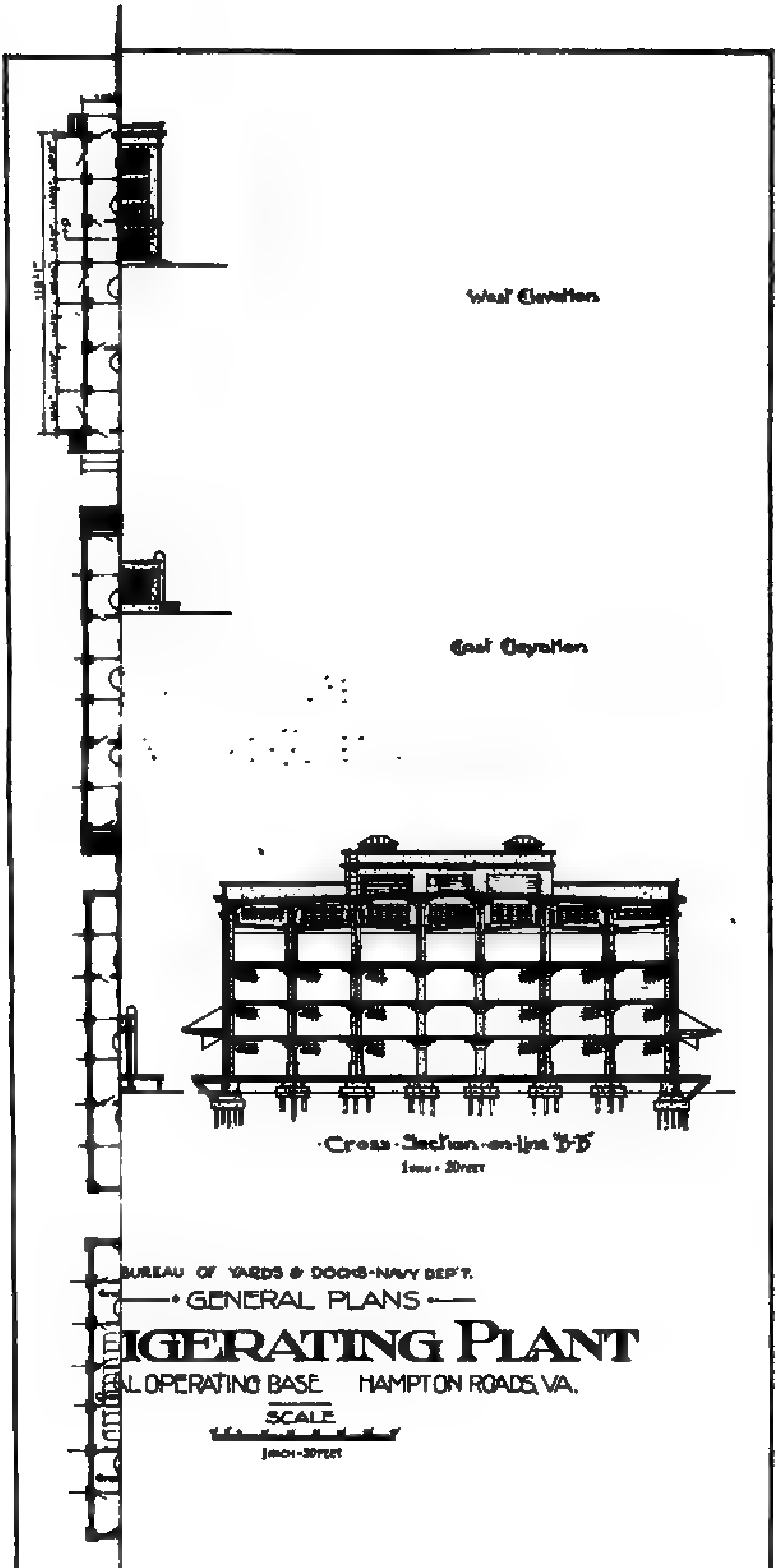
Cold storage.—Cold-storage facilities were also in considerable demand, and small plants have been installed at several locations. At the naval operating base, Hampton Roads, the need for such space, due to the enormous personnel and ships and stations to be supplied, and to the lack of available commercial facilities, made it imperative for the Navy to construct its own cold-storage and ice-manufacturing plant.

The building is 118 feet wide by 263 feet long. The main part of the building, 194 feet long, is four stories high, with a coil loft additional. Each of the lower floors is divided into six longitudinal

Emergency storehouse, Navy Yard, Philadelphia, Pa.

Temporary general storehouse, Navy Yard, Puget Sound, Wash.

Cold-storage warehouse and ice plant, Naval Operating Base, Hampton Roads, Va.


West Elevation
East Elevation
Cross Section on line "B-B"
BUREAU OF YARDS & DOCKS-NAVY DEP'T.
GENERAL PLANS
IGERATING PLANT
AL OPERATING BASE HAMPTON ROADS, VA.
SCALE

insulated compartments devoted to cold storage, the inner compartments in general to be maintained at temperatures to 30° below freezing point and the outer ones to freezing or higher temperatures. The fourth floor is divided into 14 compartments, the 4 outer of which are devoted to freezer storage and the inside 10 to sharp-freezing compartments (zero Fahrenheit).

A lean-to building, one story high, 69 feet long, separated from the main storage area by a corridor, contains the engine and compressor room, the freezing tanks for ice manufacture, and ice-storage space. The present ice-manufacturing capacity of the plant is 900,000 pounds per day, and space is provided for the addition of more units.

The construction of the building framework is similar to that of the permanent general storehouses, except that windows are necessarily omitted in storage areas. All walls and partitions, roof, and main and fourth floors are heavily insulated with cork board, and refrigerator doors are used throughout the storage areas.

Two electric elevators are provided to carry meats and povisions to freezing and storage rooms, and six spiral gravity chutes are provided for carrying meats and provisions from freezing and storage compartments to the main floor for shipment. A monorail system is provided for handling meats from loading platforms to the fourth floor via the elevators.

Boat storage.—Several boat-storage buildings, of various capacities and types of construction, have been erected. The largest of these was constructed for the storage of heavy and bulky general storage as well as of boats at the Philadelphia yard. It has a steel frame, hollow terra-cotta tile walls, wood roof, and concrete floor, and is 267 by 502 feet in maximum dimensions. The main aisle is 65 feet wide, and is equipped with 20-ton traveling cranes; two side aisles are each 50 feet wide, and are equipped with 10-ton traveling cranes; four smaller aisles, each 25 feet wide, and one of which is provided with 5-ton bridge cranes, are located along the south side of the main aisles.

At Mare Island a timber building 80 by 320 feet was constructed, with a 25-ton traveling crane, and racks for storing boats in three tiers.

Airplane storage.—The development in naval aircraft during the war made necessary the installation of special storage facilities for airplanes and aircraft materials at certain stations. Large buildings have been constructed at the naval aircraft factory, Philadelphia, and at the supply bases at Brooklyn and Hampton Roads.

The Hampton Roads building is three stories in height, 168 feet wide by 935 feet long, with steel frame, tile walls, steel sash, reinforced-concrete floors, gypsum roof slab, etc. An open aisle runs longitudinally through the center of the building, with a railroad track at the ground level, and with 10-ton crane service above third-

floor level, so that heavy and bulky parts, crates, etc., can be handled directly from cars to loading platforms at the various floor levels, and vice versa. The two halves of the building are connected at second and third floors by movable transfer bridges. As at the general storehouses, elevators and outside platforms for loading cars and trucks at the first floor have been provided.

This large building was constructed by the H. F. Friestedt Co., of Chicago, and was completed for partial occupancy in about eight months from the time contract was entered into.

The South Brooklyn aircraft storehouse is also of steel construction, of one story, with three main aisles equipped with 2½ and 5 ton cranes.

The Philadelphia aircraft factory, including the storehouses, is discussed in the chapter "Shore facilities for aviation."

Metal storage.—At the industrial yards, in addition to the facilities for the storage of plates, shapes, and billets at structural shops, and metal, etc., at foundries (described in chapter "Shipbuilding facilities"), a special storehouse is desirable for steel and other metal stock because of the difficulty of handling heavy material in storehouses designed for the lighter loads of general supplies, and because of the deterioration of metals stored in the open. The need of storage facilities for greatly increased stocks of metals to be carried because of the organization of the Pacific Fleet, following the armistice, made such a building a necessity at Puget Sound. The metals storehouse being constructed at that location is 65 feet wide by 260 feet long, and forms one-half of the complete project. It will be of one story, steel-framed, and will be equipped with 5-ton cranes spanning the width of the building.

A permanent metals storehouse was constructed at Boston, and temporary buildings for the same purpose at New York and other stations.

Lumber storage.—Among the many pressing problems approached in 1916 was that of lumber storage. After considerable study of the conditions at navy yards and of the report of the then recent investigation conducted by the Forest Service of the Department of Agriculture, a type plan was prepared for a complete lumber storage layout. This typical plant covered an area about 450 by 1,000 feet, provided a receiving and sorting shed 60 by 30 feet, an open-air storage area 200 by 700 feet served by standard-gauge tracks and locomotive cranes, storage shed 188 by 500 feet, and a dry-kiln with a heated storage building 87 by 300 feet. This plan contemplated storage of lumber generally on skids, of concrete piers and steel rails, raised from the ground to allow ventilation of piles, and canted toward one corner to allow drainage in both directions. Adequate surface drainage (and subsurface drainage, where necessary) is contemplated, with

Partial interior view, boat and general storage building, Navy Yard, Philadelphia, Pa.

Boat-storage building (timber), Navy Yard, Mare Island, Calif.

Aircraft storehouse (8-story), Naval Operating Base, Hampton Roads, Va.

Lumber-storage building No. 1022, Navy Yard, Charleston, S. C.

Lumber-storage building No. 1078, Navy Yard, Charleston, S. C

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Lumber-storage building, Navy Yard, Portsmouth, N. H.

One of two 1,400-foot merchandise piers, Naval Operating Base, Hampton Roads, Va.

a view to eliminating continued dampness and consequent hazards of rotting infections. A fire-protection system is worked out for the entire area, including automatic sprinklers for buildings; standard and narrow gauge tracks are indicated for linking up the various parts of the lumber yard in order to facilitate direct receiving, transferring, and shipping of lumber.

While it was not anticipated that this plan could be followed in its ultimate detail in the installation of lumber storage at any particular navy yard, nevertheless its preparation was considered desirable as a standard guide for provisions to be made in the design of new plants or additions to existing ones.

Since 1916 extensions have actually been made to a number of lumber storage areas and buildings at various yards and stations, including Portsmouth, Boston, New York, Philadelphia, Norfolk, Washington, Charleston, Mare Island, Puget Sound, and outlying stations. At Philadelphia a new lumber-storage plant (including dry-kiln and heated and open storage) was designed and constructed in connection with the naval aircraft factory (see chapter "Shore facilities for aviation").

Early in 1918 the congestion in lumber storage at Norfolk had become so great that it was necessary to secure space for this purpose outside the yard. Accordingly a tract on the Elizabeth River adjoining the navy yard was secured, and over 80 acres of this land were developed during the summer and fall of 1918. This emergency development (known as the "lumber annex" to the navy yard) included clearing, grading, and drainage operations in addition to the construction of the required lumber bearers, 10 sheds (six 40 by 400 feet, two 70 by 400 feet, and two 250 by 770 feet), about 6 miles of standard-gauge railroad track, and 1½ miles of road. Storage was thus provided for what was said to be one of the largest stocks of lumber in the world.

Freight sheds and piers.—Another important part of the modern storage development planned for most of the larger yards is a shed for receiving and shipping miscellaneous yard freight. In some instances a special freight pier is also contemplated to prevent congestion of industrial water-front facilities and to expedite the handling of supplies, loading of supply ships, etc.

At the Mare Island yard a freight shed has long been an urgent need, which need was greatly augmented on account of the war and the expansion of the Pacific Fleet. To meet this need a frame building has been erected on the water front at the yard terminus of the causeway connecting yard and mainland—a location admirably suited for receiving and shipping by water, rail, or truck. The part of this building at present constructed is 50 feet wide by 300 feet long. It

is set at right angles to the water front, with a railroad track along each of the long sides. The floor is 4 feet above track grade for convenience in trucking freight, and an adjustable inclined apron, with truck escalator, is provided at the quay wall for unloading from boats. This building is described because embodying the essential features of the more elaborate freight shed project proposed for the large navy yards.

Although urgently needed, no piers have been especially constructed for freight and merchandise handling except the two new 125 by 1,400 foot piers at the Hampton Roads supply station described hereinafter.

FLEET SUPPLY BASES.

South Brooklyn, N. Y.[1]—The spring of 1917, with the Navy at war, developed many gigantic problems, among which was the purchase, assembling, and storing of upwards of $100,000,000 worth of merchandise covering some 30,000 different items. The Bureau of Supplies and Accounts were charged with the procurement of these supplies, and it was the duty of the Bureau of Yards and Docks to provide adequate facilities to insure the assembling and storing of these purchases in the most efficient manner.

An inspection of the principal ports where supplies were to be assembled, namely, Boston, New York, Philadelphia, Baltimore, and Norfolk, developed the fact that the facilities at the disposal of supply officers there were of an obsolete type. It would appear that when a building was not fitted to be used for any other purpose, it was adjudged fit for the storage of merchandise and forthwith turned over to the supply officer. Hence, at the beginning of the war the storage warehouses to be found at navy yards and naval stations were not designed for the business that was being conducted in them.

Operating under war emergencies the correction of these conditions was extremely difficult, and in a great many cases impossible. The bureau, however, began a study of the situation immediately, going into the nature of the various commodities that were purchased, stored, and distributed, and taking into consideration the points from which these commodities were assembled, and also whether they arrived by rail or water. This study developed that it was necessary to purchase one, two, and even three years' supplies at one time of certain commodities, as the source of supply was rapidly being exhausted by the purchases of our allies in this country. The far-reaching benefits from such foresight may be judged when it is recalled that the Navy increased its personnel from 65,000 to over half a million in 18 months.

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[1] Contributed by Commander E. S. Nugent (C. E. C.), U. S. N. R. F., (inactive), formerly project manager.

[illegible] power plant, Fleet Supply Base, South Brooklyn, N. Y.

Eight-story storehouses, power plant, and construction office, Fleet Supply Base, South Brooklyn, N. Y.

The bureau ordered a scientific study with the object of developing permanent, efficient supply depots with a full complement of railroad facilities, up-to-date water fronts, and the most modern handling devices. New York and Norfolk were decided upon as locations for the two major operations. About the 1st of December, 1917, a board, consisting of the representatives of Operations, Supplies and Accounts, and Yards and Docks, proceeded to New York to survey and report conditions facing the supply officer in that port in so far as storage space and transportation facilities were concerned.

There had just been completed at this time over half a million square feet of storage space at the New York yard. There was also constructed, under construction, or under lease nearly a million square feet of temporary storage space in the vicinity of the yard. A site in South Brooklyn adjacent to the terminal warehouse of the Bush Co. had already been selected and a tract of land taken over from the city of New York. The first buildings constructed were on this city property and were of temporary character, built of timber, each two stories in height, and 319 by 346 feet and 380 by 450 feet in plan, respectively. They were completed late in 1917. A building of the American Can Co. had been taken over for use as a naval clothing factory, as had also been one other factory building in the immediate neighborhood. The large New York City pier at the end of Thirty-fifth Street was taken over by the Navy for loading purposes.

It developed that these facilities were not even halfway meeting the requirements. With the Navy going at top speed in the year 1918, the report of the board set forth the urgent need of 3,000,000 square feet of fireproof permanent storage space properly equipped to handle upward of 100,000 tons a month in and out. The weight, number of cubic feet to store, the necessary equipment to handle in and out of stores, the nature and volume of each commodity for each month in the year as handled by the supply officer were all determined by the representative of the bureau, as was also the distribution to be made from the port of New York, not only overseas but to other points on the Atlantic coast. The source of the supply from which these commodities would flow, the method by which they would be transported to the storehouses, and the points to which they would be issued seemed to control the location of a central and distributing storage station, which afterwards came into being as the Fleet Supply Base, South Brooklyn, N. Y.

To create the transit facilities, both rail and water, which would have been necessary to insure the efficient operation of a plant of this magnitude would have been both impracticable and extravagant as a war emergency. It was therefore decided to tie in with the large industrial storage terminal already operating with a full

equipment of piers, railroad facilities, motor trucks, and general traffic arrangements.

An additional site was purchased on the northerly end of the Bush Terminals. The land purchased was served by the Bush Industrial Railroad, seven large Bush Terminal piers, and five modern piers of the city of New York; two of the latter, including the Thirty-fifth Street pier, were retained from the city for exclusive naval use. With the above complement of piers and railroad facilities the land purchased by the Navy, with the several acres (adjacent to the city piers) which were acquired under lease for the period of the war and one year thereafter, it was possible to design and construct buildings destined to meet the requirements of the supply officers in the port of New York. The buildings were fitted to the business that was to be conducted in them rather than trying to fit the business to the buildings.

Working in conjunction with the Bureau of Supplies and Accounts, the representative of Yards and Docks was able to lay out the entire amount of merchandise to be stored. It developed that a great many commodities required ground-floor storage, the average being far in excess of supplies that could be stored on the upper floors of a building. With it clearly established what amount of ground-floor space would be needed, and the amount of upper-floor space that could be utilized, the problem began to take some definite shape. It was at this point decided to construct on the land leased from the city of New York only one-story buildings of a semifireproof nature, and eight-story fireproof buildings of a permanent nature on the land purchased.

The design of the one-story buildings presented quite a problem. They were designed to handle shipments arriving by both rail and water, and departing in the same manner, some individual packages weighing as much as 30 tons. The floors of these warehouses were designed on a 4-foot slope from Second Avenue to the marginal way separating warehouses and piers. Freight cars could thus be unloaded at the Second Avenue end with their floors level with the warehouse floor, which was, in effect, an enormous ramp assisting the trucking of supplies downhill to the piers. The two remaining sides of each building would be well adapted to the transfer of merchandise by horse-drawn or motor trucks, the floor being situated at any convenient level according to the door approached.

In the design of the two eight-story buildings, which were to be 700 by 200 feet, it was necessary to consider that war conditions would not always prevail, and that the space required by the New York supply officer would materially shrink with the coming of peace. Hence the reason for the two different types of eight-story

buildings. One, a U-shaped building, was eventually to be used for manufacturing purposes, more particularly the manufacture of clothing for the Navy. Every modern equipment for elevating, lowering, conveying, or transporting merchandise was investigated and considered in the design of these buildings. It has been said that since these buildings have been under operation a carload of nails in kegs was unloaded at the freight platform, transported to and stored on the eighth floor, in the short period of 40 minutes.

The thought carried out in the design of this storage terminal was to avoid the handling of merchandise from one conveyance to another, from the time it arrived at the buildings to be stored until it actually left the premises for its final destination.

There was available, in close proximity to the site selected for the fleet supply base, the largest plant in the world producing sand and gravel for building purposes. Representatives of the bureau visited this plant and practically commandeered its output to be used in the construction of the base. There were also operating along the banks of the Hudson River large cement mills. With these two sources of supply in mind, deliveries to be made from each by water, thereby avoiding congestion and embargoes almost continuous in the port of New York during the war period, it was recommended and adopted that the major portion of the plant be constructed of reinforced concrete.

A contract was awarded the Turner Construction Co., of New York City, on a cost-plus-a-fixed-fee basis, and a representative of the bureau turned over to the company the preliminary studies which had been made, and he, together with the engineers of the contractor, and other engineers employed from time to time, whipped the plans into sufficient shape to permit the work to start 21 days after authority for the supply base had been secured from the Secretary of the Navy.

The 8-story buildings are of flat-slab design, of the same type of construction as the other permanent general storehouses described herein. The equipment of the larger of these buildings includes 2 passenger and 21 freight elevators, and in addition 3 automatic elevating and lowering conveyors ("lowerators").

The Turner contract also included the two 1-story semipermanent buildings above mentioned, designated as warehouses W-1 and W-2; a 3,000-horsepower permanent power plant and building; a railroad system and classification yard, including over 10 miles of track; and two float bridges to permit of delivery and shipment of cars and material by water as well as by land. Warehouses W-1 and W-2 are of timber and hollow-tile construction, 300 by 355 feet and 355 by 361 feet, respectively, and are located on the city property.

In addition to the buildings mentioned above, a permanent 1-story steel-frame brick and tile aircraft storehouse, 300 by 382 feet, was constructed on the city tract early in 1918. This building is provided with 5 and 2½ ton crane service and railroad facilities.

Exceedingly rapid time was made by the Turner Co. in the construction necessary to place the bulk of the supply base in operation. The two large 8-story permanent storehouses S-1 and S-2 were made ready for occupancy in seven and one-half months, and the power house was put in operation within five months of the time its construction was authorized. The Degnon Contracting Co., of New York, and the Austin Co., of Cleveland, Ohio, also made record time in the construction of the temporary buildings A and B and the aircraft storehouse, respectively.

The total expenditures for the fleet supply base amounted to approximately $12,000,000. The cost of the two 8-story concrete storehouses was approximately $2,771,000 and $2,623,000, respectively. Warehouses W-1 and W-2 cost approximately $214,000 and $295,000, respectively. The power plant, furnishing power to all of the units, cost approximately $572,000. The auxiliary construction, namely, railroad tracks, distributing systems, garage, Marine Corps barracks, office building, float bridges, fire-alarm system, etc., brought the grand total of expenditures up to the $12,000,000 figure.

Hampton Roads, Va.—A general description of the development of the great naval operating base, Hampton Roads, has been included in another chapter. Among the earlier projects undertaken at the base, in 1917, were the 6-story reinforced-concrete general storehouse, of the type already described, and the cold-storage warehouse, also described in some detail earlier in this chapter. Besides these two permanent buildings, seven large temporary buildings (two 265 by 720 feet, two 100 by 700 feet, two 45 by 160 feet, and one 115 and 45 by 350 feet) were completed during 1917 and 1918, and various open-storage facilities were provided for such materials as nets, chain, mines, etc. During 1919 and 1920, the need not having decreased, and it being desirable to replace much rented storage space by Navy buildings, the development of this fleet supply station was continued by the construction of additional permanent buildings—an additional 6-story reinforced-concrete general storehouse, 118 by 442 feet; a 1-story general storehouse, 170 by 614 feet; and a 3-story airplane storehouse, 168 by 935 feet. (The latter two buildings are also described hereinbefore.) In addition a light steel building, 58 by 998 feet, was shipped from the Ford shipbuilding plant at Detroit, Mich., where it was no longer needed, and reerected as three buildings, two 396 feet long and one 196 feet long.

Two merchandise piers, 125 feet wide by 1,400 feet long, for berthing, loading, and unloading supply ships, barges, etc., have been

Fleet supply station group, Naval Operating Base, Hampton Roads, Va.

Electrical storehouse, Navy Yard, Mare Island, Calif.

Advance-base storehouse for Marine Corps, Navy Yard, Philadelphia, Pa.

provided opposite the supply station. These piers are of creosoted-timber construction and are provided with a transit shed 67 feet wide and 1,192 feet long. Railroad tracks are located on one side of the pier and ramps for loading barges and small boats on the other side.

The auxiliary improvements at the supply station include about 9 miles of railroad track, several miles of concrete and timber roads, sewers, water, and steam and electric distributing lines.

EMERGENCY COAL AND BUNKERING DEPOTS.

RESERVE COAL STORAGE.

Necessity.—To prevent a recurrence of the experience of the winter of 1917–18, when the shortage of coal on the east coast was so acute as seriously to cripple shipping out of the ports, and to provide against a shortage due to a possible blockade in rail transportation to tidewater points, a policy was formulated early in 1918 whereby emergency storage depots for coal were to be established at the principal ports. In order to guard against the possibility of interruption in the great flow of material and troops from any of the principal ports under the severest winter conditions, with the demand for coal at a maximum, five points were selected for the collection of these reserve supplies of coal, namely, Boston, New York, Baltimore, Hampton Roads, and Charleston. Mr. L. H. Sinclair, of the bureau, had engineering charge of the projects, which were under the general supervision of Commander C. D. Thurber (C. E. C.), U. S. N.

Constable Hook, N. J. (port of New York).—The first port to be provided with such a reserve storage depot was New York, where a site was selected at Constable Hook, near Bayonne, N. J., at the terminal of the Lehigh Valley Railroad. This depot was authorized by the Secretary of the Navy under date of May 6, 1918; and the Bureau of Yards and Docks, cooperating with the Bureau of Supplies and Accounts, began active development on June 5, 1918.

On the site selected there had already been constructed by the Bethlehem Steel Co. an ore-unloading dock, fitted with two ore-unloading cranes, one of the Meade-Morrison type and one of the Hulette type. The purpose of this construction was to unload Chilean ore for use in the blast furnaces at Steelton and other points. This plant was taken over under Navy order, and sufficient land immediately adjacent to the pier, owned by the Lehigh Valley Railroad, was also taken. A contract was awarded the Guarantee Construction Co. on June 5, 1918, and on July 9, 1,000 feet of timber trestle, with the necessary ground tracks, had been constructed and the first collier had started to unload, thus beginning the collection of a reserve of coal for this port.

The original contract with the Guarantee Co. contemplated the construction of sufficient trestle and ground tracks to store 250,000 tons of coal. This was added to from time to time until sufficient trestle had been built to store 700,000 tons of coal. Part of the storage was subaqueous, but all was within reach of 15-ton locomotive cranes operating from ground tracks or trestle, a provision particularly necessary in case of fire.

Considerable difficulties were experienced in obtaining material for the construction of this plant, inasmuch as all of the lumber had to be obtained from Texas. As this lumber was of such sizes as were being used for the construction of wooden ships, priorities had to be obtained in order to secure it, and expediters had to be placed on individual shipments to insure its delivery at New York. At the close of the contract there was available a storage depot of 700,000 tons capacity, equipped with twelve 15-ton locomotive cranes, four 50-ton locomotives, and fifty 20-yard side-dump standard-gauge railroad cars. The coal from the plant was discharged over a dumping trestle into barges, which were towed to the embarkation piers at Hoboken, and the coal was there loaded on transports and other vessels requiring it.

The cost of the construction of this plant complete, including all equipment, etc., was $1,011,175.

Boston, Mass.—The second port to be considered was Boston, and under order of the Secretary of the Navy, dated June 17, 1918, arrangements were made for the storage of 60,000 tons of coal on land owned by the Commonwealth of Massachusetts, and located adjacent to an existing coal plant operated by the Metropolitan Coal Co. of the city of Boston. The plant constructed at this location consisted of a cableway trestle, approximately 600 feet long, running parallel and being connected with the cableway trestle of the Metropolitan Coal Co. The coal was received over that company's receiving towers and cableway at the trestle constructed by the Navy, and there dumped and spread by locomotive cranes operating on the ground. The coal was reclaimed by locomotive cranes and dumped into barges from an elevated trestle constructed on an existing pier belonging to the Commonwealth of Massachusetts.

There were provided at this plant duplicate driving motors, electrically driven, for service in case the steam-driven cable motors of the Metropolitan Coal Co. should fail, electric current being obtained from the city of Boston. The equipment of the plant consisted of two 15-ton locomotive cranes, one 50-ton locomotive, and twelve 20-yard side-dump standard-gauge railroad cars, with the necessary clamshell buckets for cranes.

The total cost of the plant, including equipment, was $243,170.

Charleston, S. C.—After the Boston plant had been well started, attention was given to Charleston, S. C., and, under Operations

Hulette unloader, Emergency Fuel Depot, Constable Hook, N. J.

Mead-Morrison coal unloader, Emergency Fuel Depot, Constable Hook, N. J.

Loading train for delivery of coal to barges, Emergency Fuel Depot, Constable Hook, N. J.

Delivery of coal to barge, Emergency Fuel Depot, Constable Hook, N. J.

order of July 16, 1918, arrangements were made with the Southern Railway for the use of a plot of ground adjacent to their classification yards and lying immediately inshore from their coal-dumping apparatus on the Cooper River. The location of this plot of ground was approximately halfway between the city of Charleston and the navy yard, where it would insure an adequate coal supply for transports and overseas vessels departing from the Army depot at North Charleston.

A contract was entered into with the Charleston Engineering Co. for the construction of a trestle, with the necessary ground tracks, for the storage of 200,000 tons of coal. Use was made of one of the classification tracks of the Southern Railway and of a portion of the lands of the Maybank Fertilizer Co. and the Kennerty estate. This land was all leased for a period of years. The equipment consisted of four locomotive cranes with the necessary clamshell buckets, cars for the transportation of coal from the depot to the coal dumper being furnished by the Southern Railway at a price agreed upon.

The total cost of the Charleston plant, including equipment, was $271,213.

Baltimore, Md.—Baltimore was next given consideration on account of the increased volume of shipping leaving this port, on account of the congested conditions existing at New York, Philadelphia, and Hampton Roads, and on account of the construction of an Army supply depot at Curtis Bay. This plant was constructed under order of the Secretary of the Navy dated August 14, 1918, and arrangements were made with the Baltimore & Ohio Railroad for use of a plot of ground adjacent to their Fairfield classification yard, near Curtis Bay, Md. The Baltimore & Ohio Railroad undertook the receipt of coal from this plant for handling to barges over their coal tipples at Curtis Bay.

A contract was entered into with the Piel Construction Co., of Baltimore, Md., for the construction of a trestle, with the necessary auxiliary construction, for the storage of 200,000 tons of coal. Considerable difficulty was experienced in the construction of this plant, due to the lack of water both for construction work and for supply to locomotives and personnel. To overcome this handicap a contract was made as a supplement to the original for the driving of a 200-foot well on the property. Work was progressing very satisfactorily on this plant when the signing of the armistice brought construction work to a close. Construction work was canceled at this time, all of the material salvaged, and the site turned back to the owners.

In all of the cases described above it is to be borne in mind that these plants were established as emergency fuel reserves, the coal

not to be used except when current sources of supply failed. They illustrate in a striking manner the mobilization of vast, and sometimes inactive, resources demanded by war conditions. As a matter of fact, the coal reserves established as above were hardly touched, affording a sharp contrast with the plants to be dealt with in the following section.

BUNKERING PLANTS.

Necessity.—The most literal and direct contribution of the Bureau of Yards and Docks to the prosecution of the actual fighting on the western front was made as the result of a peculiar situation of comparatively late development.

Throughout the course of the war the Naval Overseas Transportation Service of the Office of Naval Operations had been operating all United States transports to and from the war zone with phenomenal success at all times. Coaling of such vessels was a necessary part of their operation, and this feature was taken care of by the N. O. T. S. at the ports of embarkation, utilizing commercial facilities which would normally remain outside the cognizance of the Bureau of Yards and Docks.

It is a matter of common note, however, that a large proportion of the American transportation endeavor was concentrated on the maximum utilization of the German shipping which had been interned in United States ports since 1914 and converted to American use following our declaration of war. Rapid bunkering of these vessels became a problem as the peak of the war effort was approached. They had formerly been coaled in German or other ports equipped to meet their special requirements. The transports of the *Mount Vernon*, *George Washington*, and *De Kalb* type were fitted with small ports near the water line, through which all of their bunker coal had to be obtained. There was little equipment at our ports of the character and capacity required to supply such coal readily to these ships, a condition which materially delayed the turnaround of transports on this side and to that extent abated the effectiveness of our participation in the war.

It was to remedy this situation at the principal ports of embarkation for men and materials that the Bureau of Yards and Docks was called upon as the agency of naval shore construction to assist the Naval Overseas Transportation Service in rushing the troops and supplies to France.

Hampton Roads and Newport News, Va.—On January 10, 1918, representatives of the Bureau of Yards and Docks and the Bureau of Supplies and Accounts visited Hampton Roads with a view to determining what arrangements could be made to increase the bunkering capacity of this port. After consultation with the chief

De Mayo elevator installation at Bunkering Depot, Pier 4, Lamberts Point, Va.

Mitchner elevators, stream fueling barge, and escalade in operation at Bunkering Depot, Pier 4, Lamberts Point, Va.

Derricks for supporting De Mayo elevators, Bunkering Depot, Newport News, Va.

De Mayo elevators in operation at Bunkering Depot, Newport News, Va.

engineer of the Norfolk & Western Railroad, the officials of that railroad decided that they could release Pier No. 4 of their coaling docks for use by the Navy, and arrangements were made to install coaling gear on this pier for delivering coal to the side-ported ships.

After consultation with representatives of the Chesapeake & Ohio Railroad, arrangements were made with them for the use of Pier No. 10, at Newport News, provided the Army, which was then using the pier, would allow the Navy to install coaling gear for use in bunkering transports. The Army officials at the port of embarkation were interviewed, and they decided to release the south side of the pier in question, whereupon arrangements were made for the installation of derricks for handling coaling gear. The type of equipment used on these piers was similar to that in use in New York Harbor by the De Mayo Coaling Co. and installed on the piers of the International Mercantile Marine in the Chelsea district. After considerable negotiation, the De Mayo Coaling Co. agreed to release their drawings and patterns for this equipment, and after numerous conferences the Bureau of Construction and Repair took over the manufacture of the same. The De Mayo equipment consisted essentially of a self-contained bucket conveyer, electrically driven, with special handling features.

Pier No. 4, located at Lamberts Point, was remodeled to take seven of these De Mayo elevators resting vertically on the apron of the pier. Hoppers were located inboard from the elevators so that coal could be dumped from the upper deck of the pier through the hoppers to the bases of the De Mayo elevators; from thence it was elevated and delivered to the side ports of the ships through cylindrical chutes approximately 16 inches in diameter. Pier No. 10 at Newport News was equipped with derricks, six in number, of 10-ton capacity, for handling the De Mayo elevators. In this case elevators were suspended vertically from the ends of the booms and allowed to reach down to the coal in barges, the elevator lifting the coal and delivering it through cylindrical chutes to the side-ported ships, as at Lamberts Point.

For coaling the offshore side of the ship, the Mitchener elevator, drawings and pattern of which were obtained from the Coast Coaling Co., was used, the machines being manufactured under the inspection of the Bureau of Construction and Repair by the Wellman-Seaver-Morgan Co. These machines are self-contained units of the bucket conveyer type, and were suspended from the outside of the ship, obtaining coal from barges lying alongside. The capacity of both the Mitchener and the De Mayo elevators was approximately 75 tons each per hour. On both the Lamberts Point and Newport News Piers electrical equipment was installed to operate the motors of the conveyers, current being delivered in each case at high alter-

nating-current voltage to motor-generators installed on the piers, where the current was converted to 110 volts, direct current. All of the electrical equipment, including motor-generators and distributing systems, was installed by James Stewart & Co., of New York. This company also performed the work of strengthening the pier at Lamberts Point and the erection of the derricks at Newport News, all the above operations being undertaken as an extra under the contract for the construction of bulkheads and piers at the naval operating base, Hampton Roads, Va.

In addition to the electrical system and wharf construction, there were constructed at Lamberts Point an office and dormitory building for the operators of the coaling equipment, and motor-generator house inshore from the pier; and at Newport News a barracks building, motor-generator house, tool house, and office building.

In order to allow the largest transports to berth at both Lamberts Point and Newport News, considerable dredging was necessary, which dredging was done under contracts with the Norfolk Dredging Co. and Morris & Cummings. Another feature of these bunkering depots was the preparation of berths so that transports could be coaled during all kinds of weather. The Roads in front of the Newport News Pier during the winter months are generally choppy, and the fueling barges had difficulty in operating continuously. Berths were provided by driving dolphins under shelter of the shore line to the south of Pier No. 12 at Newport News, thereby affording a quiet harbor for coaling operations at any time. By the installation of this coaling equipment for bunkering the special type of ships, the time of turnaround of transports in Norfolk Harbor was materially decreased.

The total cost of the work at Lamberts Point and Newport News was approximately $75,000—an insignificant expenditure for the result produced.

Hoboken, N. J.—In view of the successful operation of this equipment at Norfolk, it was decided to seek relief in the same manner at the port of embarkation, Hoboken, N. J. The Army during the progress of the war had taken over for this purpose the six piers comprising the terminal of the Hamburg-American and North German Lloyd Lines at Hoboken. These piers were designed originally to make use of equipment of the De Mayo Coaling Co., and the problem before the Navy was to furnish and install such machinery. Some of the company's equipment was commandeered for the purpose, and additional derricks and electrical equipment were installed on Pier No. 4. The first installation involved the construction of 18 derricks on the north and south sides of Pier No. 4 and the north side of Pier No. 5. Electrical equipment was available on the piers

for a portion of this machinery. It was later seen that it would be necessary to equip all of the piers similarly, including Pier No. 1 of the Holland-American Line, which pier had also been taken over by the Army for embarkation purposes.

Upon the decision to equip these piers with coaling apparatus, it became necessary to increase the electrical facilities of all of them. This involved a considerable amount of work, in that a transmission line had to be constructed from the Palisades substation of the Public Service Corporation of New Jersey and a substation had to be installed at the piers for the conversion of the high-voltage current. The equipment of this substation consisted of two 1,000-kilowatt rotary converters and one 500-kilowatt motor-generator set, with the necessary transformers and switchboard equipment. There were constructed in addition to this two motor-generator houses, each housing one 300-kilowatt set for delivering current to the extreme north and south piers. An additional feature of the electrical work was the installation of outlets on all of the piers, so that the transports when loading troops and cargo could shut down their dynamos and take current for lighting and power from the piers direct, thereby enabling repairs to be made while the work of loading was going on.

The work of equipping these piers as above described was divided into four contracts: One, for the installation of derricks on all the piers, with the O'Rourke Construction Co., for $95,477; one, for the transmission line from the Palisades substation to Hoboken, with the Public Service Corporation of New Jersey, for $30,700; one, for the construction of the substation, with George Fearon & Co., for $19,400; and one, for the electrical equipment, with Harry Alexander (Inc.), for $274,695, making a total cost for all these piers of approximately $420,000. The furnishing of all of the coaling equipment, that is, the Mitchener and De Mayo elevators, with the stream fueling barges, hoisting equipment, etc., was under the cognizance of the Bureaus of Supplies and Accounts and Construction and Repair, the Bureau of Yards and Docks constructing only that portion of the work that was fixed to the piers. Upon the completion of the electrical equipment and the delivery of the mechanical equipment, transports could be loaded with coal at the same time that troops and cargo were being put aboard, thereby decreasing considerably the time of turnaround of the transports in New York Harbor, and consequently materially assisting in expediting the movement of troops and materials to Europe.

The Hoboken project was undertaken in June, 1918, and the facilities provided were put to use as each unit became available. The whole installation was complete and in full operation by October, 1918.

Lighting.—All of the emergency fuel depots and bunkering depots were thoroughly equipped with flood lighting systems, so that operation could proceed both day and night. In some cases portable acetylene lights were used, and in the case of the Constable Hook depot the locomotive cranes were each equipped with high-power seachlights, so that the operator would at all times have a flood light on his individual operation; in all other cases the flood light system was so arranged as to cover the whole plant during the hours of darkness.

Appropriations.—The bunkering depots at Newport News and Lamberts Point (Hampton Roads) were constructed from funds under the cognizance of the Bureau of Yards and Docks, appropriation "Contingent." All the other fuel and bunkering depots above described were provided under allotments from the appropriation "Fuel and transportation, Navy."

CHAPTER XV.

STORAGE FOR FUEL OIL.

The gradual reduction in the supply of petroleum from wells in the United States had led to the recommendation by the General Board of the Navy before we entered the war that large facilities for the storage of fuel oil be constructed at various points along the coasts in order that there might be provided and held in reserve an adequate supply, which would presumably be secured from the Mexican oil fields. The construction of this storage was not considered a war project, but it was deemed of sufficient importance to be carried on during the war. The general scheme of storage which was adopted consists of groups of reinforced-concrete tanks, rectangular in plan, and placed underground, such tanks being particularly suitable for the storage of oils of low specific gravity, which the Mexican fields afford. Such oils require heating for easy and rapid handling, and the plants are accordingly equipped with apparatus for raising the temperature of the oil to a degree which will increase its fluidity. Steam coils are also installed in the reservoirs in order that the temperature of the oil may be maintained at at least 70° F., and provision is made for cooling it to 105° F. or less before it is placed on board the ship, this being required because of the fact that it is inadvisable to store hot oil on vessels carrying supplies of high explosives.

So far as funds would allow, the fuel-oil stations were provided with fire-protection systems, using a foaming mixture which forms a blanket of bubbles of carbon dioxide gas over the surface of the oil in case of fire, all automatically controlled by thermostats.

As the Navy has not abandoned the use of steel tanks for the storage of fuel oil and gasoline, the bureau has also constructed a certain amount of storage of that type.

The first of the new storage plants to be placed under construction was that at the naval station, Guantanamo Bay, Cuba. This station thus acquired an additional storage capacity of 6,000,000 gallons of fuel oil in two concrete reservoirs. Owing to the diversion of shipping, the contractor had very considerable difficulty in getting materials from the States to the station. The other storage plants which were constructed were located at the naval fuel depot, Melville, R. I., where there were constructed two reservoirs with a total capacity of

5,000,000 gallons; at the navy yard, Puget Sound, with two reservoirs having a total capacity of 9,800,000 gallons; at the naval fuel depot, San Diego, Calif., with one reservoir of a capacity of 2,100,000 gallons; at the naval station, Pearl Harbor, Hawaii, with one reservoir with a capacity of 7,800,000 gallons; and at the naval fuel depot, Yorktown, Va., where there were constructed eight reservoirs with a combined capacity of 30,000,000 gallons. The reservoir at Pearl Harbor was built by station labor, while all the others were constructed under contract.

The naval fuel depot at Yorktown is a new one, established primarily for the purpose of storing in one place a large reserve of fuel oil. When the work was started no facilities whatever were available, and it was necessary first to build a pier out to deep water. The York River is very shoal for a long distance out from shore at this point, and a wharf 2,160 feet long was necessary. It was found that at the outer end, where the depth is sufficient to permit large ships to come alongside, the bottom is very soft, and the use of spliced piles was necessary. The difficulties to be overcome were considerable, but the wharf was completed and was ready for the installation of the oil pipe line in ample time.

The fuel-oil storage plants which have been described above were not considered of great urgency, as it was not expected that they would be used during the World War. The bureau was called upon, however, to establish a certain amount of fuel-oil storage in France for the use of the naval forces operating in European waters. The first intimation that the bureau had that such storage would be required was contained in a dispatch from Admiral Sims December 5, 1917, in which he asked for five 4,000-ton tanks to be installed at Brest. This was followed by a dispatch recommending the taking over of the French fuel-oil stations at Brest, Furt, LaPallice, and L'Orient, which was approved by the Secretary of the Navy. There were three 7,000-ton steel tanks at the Norfolk Navy Yard, which had been erected, but had never been filled with oil, and upon receipt of Admiral Sims's dispatch a message was forwarded asking if these tanks would not be satisfactory in place of the five smaller ones requested. A favorable reply being received, the bureau proceeded immediately to disassemble these tanks, arranging with the supply officer at the Norfolk yard to attend to the shipment. At the same time requisitions were prepared for other tanks, as follows: Two 560-ton tanks for oil and one 150-ton tank for gasoline for installation at Brest, and nine 3,500-ton fuel-oil tanks, three each to be installed at the stations of Furt, LaPallice, and L'Orient, as recommended by Admiral Sims.

The three large tanks at Norfolk were taken down promptly and were shipped abroad in March, 1918. The securing of the 12 smaller

tanks for which requisition had been prepared was somewhat delayed, as the contractor for them deliberately held up the work of fabrication on the nine large ones, raising one question after another as to the interpretation of specifications, etc., until on April 23, 1918, the contract was annulled. The bureau then set about locating works where the nine oil tanks could be fabricated quickly, and as a result two contracts were made four days later, on April 27, one for four tanks and the other for five.

In order to connect up the new tanks at the stations mentioned above and to increase the handling capacities, a considerable quantity of piping, valves, and fittings and a number of new pumps were required. A list of these was received from Admiral Sims on February 2, 1918, and requisitions covering them were issued on February 5, February 11, and February 18. On March 12 a request was received for two additional pumps at Brest, and a few days later the bureau located suitable equipment and issued requisitions to cover it.

All of the material described above which was purchased on requisition was delivered at the navy yard, Philadelphia, for transshipment to France. Considerable difficulty was found in obtaining cargo space for it, as priorities had been established on Navy transports, which provided that first choice should be given to ordnance, followed by radio material, the fuel-oil equipment having to take any space which might then be left.

The coordination of bureau activities with the demands of the war is well illustrated by the history of these fuel-oil projects as they actually took shape on French soil under the direction of officers of the Corps of Civil Engineers. The following personal account is supplied by one of these officers, Lieut. C. P. Conrad (C. E. C.), U. S. N. (resigned):

The fuel-oil tanks constructed at Brest were of great strategic importance to the Navy, as they made it possible to double the number of destroyers based on Brest and thus to double the protection given to transports and store ships against submarine attack.

The French oil depot had two tanks of 1,000 tons each and two of 2,500 tons each, a total capacity of 7,000 tons. Since this was less than the cargo of one modern transatlantic tanker, these vessels did not come direct to Brest, but went to England, Brest being supplied through the British Admiralty by small tankers. It early became evident that our needs could not be supplied in this way and that additional storage must be provided at Brest.

In December, 1917, word was received by the force commander that three tanks of 7,000 tons capacity each were available at a navy yard in the United States,[1] and could be knocked down for shipment to Brest if space could be found to erect them there. The situation was explained to the French, who offered us a triangular tract in the dockyard, back of their oil station, on a narrow strip of made ground fronting on the inner harbor. This location made

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[1] Norfolk; see above.

it imperative to observe all precautions against fire and overflow. Our preliminary calculations showed that the tanks with necessary basins around them could be fitted into the parcel by placing them partly in excavation. Request to ship the tanks was cabled to Washington, and the French set about to prepare the foundations.

The characteristics of the made ground rendered it necessary to carry these to bedrock, 15 to 25 feet below. Wooden piles could not be used, as the French wanted a permanent structure. Material was not obtainable for reinforced concrete piles, so the French proposed to construct the foundation slab of concrete 3 feet thick, supported on five concentric masonry walls extending to rock. The contractors who had just finished two 800 by 120 foot dry docks near by and still had their equipment on the ground were invited to bid. They submitted reasonable unit prices for the work, but wanted 10 months' time.

We then found a site in an unused quarry on the hillside back of the French tanks, and about 90 feet above high tide, where our tanks could be placed directly on the ground with earth embankments around them. This setting seemed to us more rapid and economical than that on the flat below, but the French were unalterably opposed to it. They did not want us to set the tanks outside the dockyard, and did not want us to block a quarry which would be used again when harbor-improvement work was resumed. They induced the contractors to cut down the time to four months for completing the first foundation, and then after communicating with Paris made it clear that they would withdraw their cooperation unless we accepted the site first offered. Four months was the minimum time in which we could expect the tanks to arrive, so the dockyard site was adopted and work started on the foundation on January 14, 1918.[1]

The contractors used a gigantic endless-chain bucket excavator, of the type the French left us at Panama, to remove the earth down to bedrock over the entire area of the foundations. Then they built up the five concentric masonry walls to elevation —12 feet below ground and backfilled between them, bringing the earth to a crown in each annular space. A concrete slab was then placed over all, having a minimum thickness of 3 feet over the earth crowns. This concrete was laid dry and rammed into place, but remained porous. It was mixed by dumping a small car of mortar, made in a batch mixer similar to our concrete mixers, into a tremie with two cars of dry crushed rock. As the mortar and the rock dropped together through the 16-foot tremie they were more or less perfectly mixed by fixed bars within this cylinder. The strength of this concrete was never tested, as the factor of safety in the design seemed to be large enough to take care of any weakness in the materials.

The masonry walls forming the basin were carried to a height of 10 feet above ground, and between adjacent tanks the division wall was made 3 feet higher than the top of the tanks "to prevent the spread of fire from one basin to another should the tanks explode."

The contractors stipulated in signing the contract that labor must be procured for them by the Government. Common labor was imported from Spain, and German prisoners were successfully used as masons, as the local supply of labor had been exhausted by French military and industrial needs.

The foundation work made good progress, the first basin being 75 per cent complete when we received word in April that the tanks had been shipped. Machinist La Tourette, U. S. N. R. F., arrived about May 1 to take charge of erection and we collected the scattered force that had been sent over for this work. Most of the men had come in an aviation draft, without ratings to desig-

[1] Tanks were shipped in March; see above.

nate them, and had been assigned as seamen to various air stations. When a call was sent out for them commanding officers were loath to give them up, as they were the most valuable men on the stations for construction that was going on everywhere at that time. Erecting equipment for tank work had been ordered with that for high-power radio construction, but at the time the Brest tanks were built no American equipment was available. Fortunately ship construction was not active in the French yard and we were able to borrow and have made there the tools we needed. An air line of pipe borrowed from the naval air station, Ile Tudy, was laid a distance of 1,700 feet from the compressors that were to serve the new French dry docks. Wire-wound air hose was our greatest lack, and fortunately a shipment of 1,000 feet came in for the *Prometheus* at this time, and Capt. I[illegible]on allowed us to keep half of it.

Fortune favored us in a much bigger way, for the transport bringing the plates, after it struck a rock at the entrance of Mengam Channel, was safely brought alongside the dock and unloaded.

The contractors completed the first foundation on time, May 14, 1918. The first bottom was fitted and bolted May 23, when Admiral Wilson drove the first rivet. The top ring of this tank was completed June 15, and a waiting tanker immediately pumped her oil in. The roof was riveted with the tank full of oil, resulting in unsavory baths for two of the buckers-up. This gang of 90 men continued work day and night until the three tanks were entirely completed, September 15, 1918, increasing the storage at Brest to 28,000 tons, or four times the capacity of the French depot. Additional pumps and distribution pipe to fuel 15 destroyers in six hours had also been ordered but were not received in Brest until after the armistice.

Nine tanks of 3,500 tons capacity each were ordered to be placed, three at L'Orient, three at La Pallice, and three in the Gironde River at Furt. Complete pumping equipment and distribution systems were also ordered for these stations. The tanks arrived about September 1,[1] and active work was in progress at all three stations when the armistice came. The French Navy agreed to take over the material for L'Orient and La Pallice, but requested that erection be stopped as the tanks might be more useful to them elsewhere. The tanks at Furt were completed and sold to the French oil company owning the land there.

The French Navy very willingly took over the tanks at Brest, and although there had been no previous agreement to that effect assumed the entire cost of the foundations and agreed to pay the United States Navy for the tanks at the same price per ton as their tanks had cost them in 1914. By this agreement the French assumed 78 per cent and we 22 per cent of the war-time cost of tanks built for our own needs.

[1] Contract let for fabrication Apr. 27; see above.

CHAPTER XVI.

RADIO STATIONS.

As the naval radio stations are operated by the Bureau of Engineering, the initiation of new radio projects rests with that bureau. The design and construction of all public works relating to them, however, are handled by the Bureau of Yards and Docks, which accordingly, when requested to do so, has designed and constructed many new stations, as well as additions to the facilities of existing ones, the work covering self-supporting towers, varying in height from 150 to 820 feet, guyed masts, operating buildings, power houses, quarters, barracks, water and sewerage systems, fences, and flood lighting.

The new high-power radio stations at San Diego, Calif., Cavite, P. I., and Pearl Harbor, Hawaii, were placed in commission about the time that the United States entered the war. At each of these stations the installation consisted of three 600-foot triangular self-supporting steel towers with the necessary buildings, these stations forming units of a chain of high-power stations capable of long-distance communication. While this chain would have been extended in any event, the work was considerably expedited on account of the needs which arose for uninterrupted communication during the war. In October, 1917, the bureau awarded contracts for towers and buildings for a high-power station at Cayey, Porto Rico. The towers are three in number and are 600 feet high, all of the standard design adopted by the bureau for such structures.

Shortly after our entrance into the war it was decided that a new high-power station should be constructed at Annapolis, and in November, 1917, the bureau entered into a contract for four 600-foot towers, to be constructed on Greenbury Point, across the Severn River from the Naval Academy. At the same time the construction of an operating building, quarters, barracks, wharf, water-supply system, fence, and all other public works necessary to a complete station was undertaken, and the work pushed in every possible way. The winter of 1917–18 was a severe one, and the erection of high steel towers was a most difficult operation, owing to the snow and sleet which covered the steel. The station was completed, however, during the summer of 1918, and the first message was sent to France

early in September. At the time of its completion the Annapolis station was the most powerful one in the United States, with the exception of the one at New Brunswick, N. J., and was one of the most powerful in the world.

In January, 1918, plans were completed and a contract let for the fabrication of the steel towers for the mammoth transatlantic radio station to be erected at Croix d'Hins, France. This great project is reserved for a special description, appended at the end of the present chapter, from the pens of the civil engineer officers in charge of construction at that station prior and subsequent to the armistice.

In addition to the high-power radio stations which have been described briefly above, a considerable number of installations of towers and buildings for radio stations of more moderate power were constructed. Among these may be noted the two 300-foot towers with operating building and quarters at the navy yard, Philadelphia, which were completed in August, 1917; the addition of one 300-foot tower to the two existing ones at the navy yard, Charleston; the two 200-foot steel towers at St. Thomas, Virgin Islands; the erection of two masts at Port au Prince, Haiti; and the construction of barracks, operators' quarters, and Marine Corps quarters at the receiving station, Bar Harbor, Me. The addition of these structures at the latter station was of great importance, as Bar Harbor was used for the receipt of all messages from abroad.

Another project of comparatively small importance but of some interest was the station established on Navassa Island in the West Indies, where the existing lighthouse was made to serve as one of the masts, and a wooden spar 65 feet long was secured for the other. This spar was obtained from the Norfolk Navy Yard and was hurriedly forwarded by one of the ships of the Panama Railroad Steamship Co. As the steamer makes no stop at Navassa, where there is no suitable landing, instructions were given that the spar be thrown overboard while passing the island, in order that the men quartered there might pick it up and tow it ashore.

In addition to the foregoing, the bureau carried through a large number of minor projects at Charleston, S. C.; New Orleans, La.; Keyport, Wash.; Seward, Alaska; Key West, Fla.; Portland, Me.; Portsmouth, N. H.; North Truro, Mass.; and St. Augustine, Fla.

After negotiations had been handled through the State Department the bureau prepared drawings and requisition for twenty 200-foot and four 300-foot self-supporting steel towers for the Cuban Government. These towers were fabricated in the United States and shipped to Cuba.

THE LAFAYETTE RADIO STATION, CROIX D'HINS, GIRONDE, FRANCE.[1]

Historical.—As the number of American troops in France increased it became apparent during the latter part of 1917 that the capacity of existing means of transatlantic communication might be taxed beyond their maximum capacity by the constantly increasing volume of messages. Added to this condition was the ever-present possibility that communication by cable might be hampered, if not entirely suspended, by the operation of enemy submarines, and that transatlantic radio communication might be similarly affected by aerial attack or by interference from powerful radio installations in enemy territory. Gen. Pershing requested as a war measure that immediate steps be taken to provide means of communication that would assure freedom from such risks, and accordingly the decision was taken to erect at some point in France a radio station that could be relied upon to transmit messages across the Atlantic under any and all conditions that could be foreseen, including attempted hostile interference by radio.

Because of conditions created by the war, it was evident that the radio apparatus and the towers would have to be supplied by the United States, and on account of the special nature of the entire equipment as planned it was obvious that the installation and erection could best be performed by American personnel.

Inasmuch as radio matters in the United States were handled exclusively by the Navy during the war, and for the additional reason that the Navy had had extensive experience with the construction and operation of high-power radio installations, the work of designing, fabricating, installing, and erecting the radio apparatus and supporting towers was intrusted to the Navy Department, the bureaus concerned being those of Steam Engineering, which had cognizance of the general features of the design and radio characteristics of the station, and Yards and Docks, in charge of the design and erection of the towers and of the public-works features in general.

The French Government objected to the presence of a force of civilians working under a contractor, on the double ground of the discontent that might be engendered by the comparatively high wages that such civilians would enjoy and the difficulty of exercising adequate military control over such a contractor and his employees. It was accordingly decided that the whole operation in France should be executed by a military force.

The loftiest radio towers theretofore built by the Navy Department were 600 feet in height, but for the reasons already stated it was decided that those for the new station in France should be 820 feet high. The Bureau of Yards and Docks at once began the design of the unprecedentedly high self-supporting towers, and by strenuous work was able to make a contract in January, 1918, for the fabrication of the towers and their delivery at the navy yard, Philadelphia, Pa., for transshipment overseas. The work in the bureau's drafting room included not only the general design but also the elaboration of all shop details, in the interest of saving all possible time in the letting of the contract and the fabrication of the work; and it is greatly to the credit of the bureau's designers and draftsmen in this instance that not only has the general design of the towers been the subject of most favorable comment by noted French engineers who have visited the site during and after erection of the steel, and who have scrutinized the design quite closely, but also that there was sub-

[1] Contributed by Commander F. H. Cooke (C. E. C.), U. S. N., in charge of construction at this station up to the date of the armistice.

stantially no difficulty experienced in the erection of the towers attributable to errors in detail dimensions, despite the high pressure under which the design was prepared and the great speed with which it was accomplished.

After extended conferences between American and French radio experts, it was decided that the station should be provided with eight towers arranged in two parallel rows of four each, the towers being set on the centers of 400-meter squares, the rectangle formed by the centers of the end towers being thus 400 by 1,200 meters, or 1,312 by 3,937 feet.

The site selected for the station was the little French country village of Croix d' Hins, in the Province of Gironde, about 14 miles southwest of Bordeaux. The station was known unofficially as the Liberty radio station until the name Lafayette was assigned by the President.

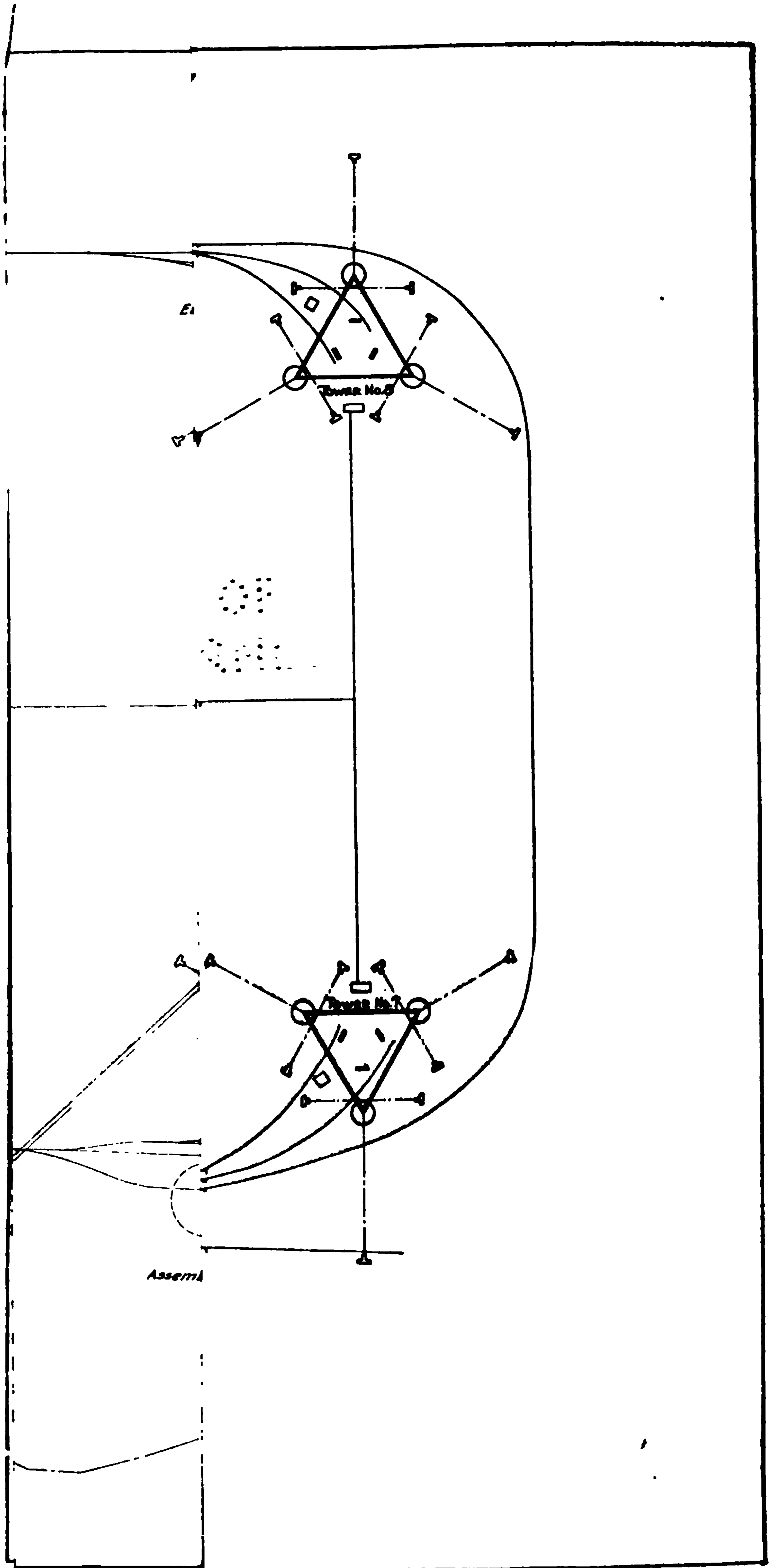
Preparatory work.—The design of the towers having been completed and the contract placed for the delivery of the fabricated material, it was next necessary to procure the equipment for erecting the towers and housing for the personnel to be sent to the station. The force itself had to be assembled. It was ascertained that it would be necessary to construct a self-contained encampment, which, in view of its isolation and the distance from the excitement of the fighting, ought to be in extent and completeness greatly superior to an ordinary construction camp, for the sake of creating and maintaining contentment and efficiency in the personnel. The outcome was a camp which, it is believed, was unsurpassed in its provisions for comfort and recreation, and the time and labor expended on it were amply justified by its results in morale.

Taking into account the pressing need of the utmost dispatch in putting the station in operating condition, the bureau ordered erection equipment on a most liberal scale. The program for the erection contemplated work on all eight towers simultaneously, and equipment was ordered and personnel assembled on this basis.

Included in the erection equipment were motor-driven hoists in considerable number. Comparatively late in the placing of these orders, it was learned that electric current would not be available at the site before a prohibitively late date, and, inasmuch as the hoists had been ordered on information from France to the contrary effect, material had to be ordered for a 15-mile high-tension power-transmission line to be installed by the radio detachment as an additional item.

The collective height of the eight towers at this station is 6,560 feet, as compared with the 1,800 feet of the ordinary three-tower navy radio station and with 2,400 feet at the Annapolis station. The erection of high radio towers calls for expert work, and accordingly a force of approximately 150 skilled steel erectors were enrolled in the Naval Reserve Force especially for this job, in addition to approximately 450 men in a wide variety of ratings for service other than work aloft on the towers. A number of officers were enrolled in the Naval Reserve Force for the paramount duty of supervising and directing the work of the steel erectors, and the rapid progress of erection on the first four towers was directly due to the efficient work of these officers and men, without whose skill the elaborate and extensive erection equipment would have been of but little avail, particularly in view of the dizzy height at which most of the work had to be done.

Included in the personnel especially detailed were an electrical engineer and a force of experienced linemen, whose expeditious construction of the power-transmission line quickly provided the camp with light and the erectors with power.



› Station. General I 87022—21. (To face page 368.)

The station's organization included a supply department, upon whose efforts depended the highly satisfactory messing and canteen service, in addition to that department's ordinary functions of handling and accounting for material. There was also a complete hospital unit, including an officer of the Dental Corps. Recreational and amusement features were very successfully administered by the chaplain and other officers on the station.

The camp.—The first contingent of officers and men arrived in France in April, 1918, and the officers charged with the construction of the camp and the erection of the towers made their first inspection of the site on April 29. This site is a large clearing, about 1 mile wide by 3 miles long, in the midst of the pine forests that cover a large part of the flat country of southwestern France. The site is practically level, and the soil is a fine sand of indefinite depth. At the time of this examination the effect of the winter rains was still apparent, the ground being saturated and the surface covered with standing water in considerable areas. The drainage system consisted of several wide and comparatively shallow ditches traversing the site and leading to a small stream some miles away, and it was at once apparent that the sanitation of the camp would require careful treatment.

On account of the comparatively late date at which portable buildings and their appurtenances had been ordered, authority had been obtained to divert a number of portable buildings from the aviation stock already in France for use in beginning the construction camp. The first shipment of these borrowed houses arrived at Croix d'Hins on May 28. The first draft of enlisted men, about 30 in number, arrived on the 29th, and were quartered temporarily in a French "Adrian" barrack that fortunately was at the site. This barrack was very kindly loaned to the Americans by the French contractor for the tower foundations, after extensive inquiry in Bordeaux and Pauillac had developed the impossibility of obtaining any tents from either the American Army or Navy, or from the French.

Emergency messing accommodations for this first contingent had also to be made, and after an unsatisfactory experience with a wayside restauranteur, sufficient galley and mess equipment were improvised to set up independent subsistence arrangements of a temporary kind.

These first days were very rough by contrast with the later period after the camp was finished. Later drafts were received directly into well-ventilated electric-lighted barracks, where they slept on comfortable cots, with more than the officially prescribed air volume per man. They messed at clean, comfortable tables in cheerfully lighted, well-ventilated mess halls, and obtained their food fresh and hot from steam tables supplied by a large galley plentifully equipped with the most modern American facilities.

In the early days the problem of water supply was perplexing. The local wells were at once condemned by the sanitary officers, and for a number of weeks the water used for drinking and cooking was hauled from Bordeaux in a tank wagon borrowed from the Army, whose leakage was at first a serious factor in the camp's activities. Water could be had by digging holes almost anywhere to a depth of about 5 feet, but this was not suitable for drinking or cooking, nor was it obtainable in any quantity for other purposes. Nevertheless it was the only recourse for bathing, and, until better facilities were installed, it was bailed out in cans and so used. The contrast between this process and the luxury of the hot and cold showers and modern plumbing subsequently placed was very striking.

When the first contingent arrived at Croix d'Hins there was a French-built railroad siding connecting with the main line of the Midi Railroad, but extending only a short distance into the site. The only means for propelling the cars within the site was by man power, supplemented at times by a team of horses, hired from a near-by farmer, and the work of unloading material and erecting the camp was frequently interrupted by a call for all hands to push the freight cars. The French contractor for the tower foundations was also receiving considerable material, and inasmuch as the railroad wye was not then built, frequent perplexing problems arose as well as some arguments between the Americans and the French as to the right of way on the single track. After scouring Bordeaux and vicinity an old "Sotteville" locomotive, built before the Franco-Prussian war, was located at a small railroad station outside the city, and was hired by the Americans. Its advent at the station was hailed with delight by both the French and Americans, whose enthusiasm was evidenced by the respective pseudonyms by which the two nationalities designated it. Its performance might, in general, be characterized as "temperamental," but by dint of careful handling and judicious repairs it was made to play an invaluable part up to the arrival of the efficient new American switching locomotive in September, 1918.

The problem of a permanent water supply remained unsolved until those in charge of the camp were directed to the out-of-the-way shop of an elderly Bordeaux citizen, who was the patentee of a successful system for extracting a continuous flow of water from the sand strata of the region. A contract was made with him for one well to supply at least 10 cubic meters per hour, and after considerable delay in obtaining the requisite materials, he began operations. His efforts were watched with considerable solicitude, and the relief was great when he struck a copious flow of water at a depth of 32 feet below the surface. In the meanwhile, pending the arrival of the 12,000-gallon tank and steel tower, ordered in the States, a 3,500-gallon tank had fortunately been found at a winery some miles from Bordeaux and had been set up on 12-foot posts in anticipation of the striking of water. A gasoline-driven pump, of limited capacity, was borrowed from the well contractor, and did service for many weeks. This temporary installation wrought an immediate and welcome change in bathing facilities for the personnel, inadequate as were the pump and piping installed, and it was not long until the first permanent bathhouse, with heating apparatus, was completed and supplied from this source.

Later on another well was sunk, and by means of two electrically-driven pumps, obtained from the Army at Tours, and by piping obtained from the States, or borrowed from sundry French localities, an adequate supply of potable water was piped to all parts of the camp, with fire hydrants and hose at various points—all in striking contrast to the water wagon lumbering and splashing its course along the weary miles and the shallow pools of uninviting water at the bottom of holes in the ground.

On account of the flatness of the site and the general condition of saturation to be expected when the winter rains should begin, and to meet the requirements of sanitation and decency, two septic tanks were built alongside the main drainage ditch that has been referred to. The drainage from the camp was led to these tanks by a system of sewers built above ground, as only by these means could it be assured that the tanks would not be flooded in winter. Winters in this part of France are characterized by chilly and rainy weather rather than by low temperature, and no trouble was experienced in either of the winters during which the sewer system functioned from flooding or freezing, nor has there been any trouble from the sanitary standpoint.

The completed camp is indicated on the accompanying layout map, figure 1, and comprised the following buildings:

	Square feet.
20 barracks	42,620
Mess hall and galley	9,655
Officers' quarters	4,700
Four latrines	4,400
Recreation building	5,200
Refrigerator building	700
Laundry	4,300
Two administration buildings	4,300
Six storehouses	14,215
Sick bay and hospital	3,700
Canteen, carpenter shop, electrical storehouse and office, guardhouse, pump house, boiler house, garage, tool house	5,467
Total	97,757

In addition to the foregoing buildings there were constructed a motor-generator house and an assembly and repair shop, aggregating 8,193 square feet, and also engine houses at the towers and various sheds. The procurement of the material for all of these buildings and their appurtenances and their delivery at the site required a great deal of work. For example, it was necessary to run trains of trucks and trailers a distance of some 50 miles to obtain lumber from an American lumbering camp in the pine woods; it was necessary to set up a service of motor trucks between a quarry and the railroad station at Dax, about 80 miles from Croix d'Hins, to obtain stone for road construction; it was necessary to go to Tours with a long list of needed materials, most of which was supplied from the A. E. F. depot at Gievres, some 40 miles from Tours; the A. E. F. establishments at Bassens and St. Sulpice, on the opposite side of the river from Bordeaux were continually solicited for materials, as was the Navy aviation base at Pauillac; and in addition there was a constant combing of French sources of supply, sadly depleted by the war conditions. The outcome of all this was a camp which, it is believed, was not surpassed anywhere in France in completeness and comfort, and the thanks of all who enjoyed these comforts are due, in great measure, to the helpful cooperation of the Army and Navy organizations in France, and to the French authorities who did all they could to assist the enterprise.

No account of the Croix d'Hins camp is complete without favorable allusion to the recreation building. Whatever expense was entailed by its erection and adequate functioning was more than repaid in the contentment and genuine enthusiasm it served to inspire. Its effectiveness was reflected in the whole spirit in which the job was attacked; and the officer in charge of the completion of the towers, after the suspension of work following the armistice, has voiced the opinion that an outlay of $10,000 on the recreation building and amusement facilities would have been justified and would have paid large returns in maintained efficiency.

Transmission line.—As finally built, the transmission line constructed by the Americans was about 11 miles in length, and supplied current at 11,500 volts, three-phase, which was transformed at Croix d'Hins to 2,200 volts by a bank of three single-phase transformers, and again transformed to 220 volts direct current and 110 volts alternating current by motor-generators and secondary transformers, for power and light, respectively. The route traversed pine forests, country roads, and private grounds, and in its final form was the result of a great deal of scouting and forest ranging on the one hand; of negotiation with French landowners and officials on the other. Shortage of materials and breakdown of transformers diversified the geographical and linguistic problems

from time to time, but the work was carried to a successful conclusion by untiring and persistent effort, and the camp burst into a blaze of light on the night of September 3, 1918. At first the current was shut off at 10 p. m. from the French station in the outskirts of Bordeaux, but before long authority was obtained for all-night service, which continued to the end of the work.

Although six steam hoists had been provided in addition to the electric hoists, the latter were used exclusively in the completion of erection after the armistice; the average daily rate of consumption of power was 120 kilowatts, the maximum for any one hour being 300 kilowatts.

Tower foundations.—The design and construction of the foundations for the main towers were handled entirely by the French. These foundations are of an unusual type, consisting essentially of a reinforced concrete disk about 40 feet in diameter at substantially the surface of the ground, supported by 28 precast concrete piles driven to refusal, and surmounted by a central pedestal 12 feet high and approximately 8½ feet in diameter, braced to the bottom disk by inclined reinforced-concrete buttresses. The steel shoes for the tower columns rest in recesses formed in the top of the pedestals, susbequently filled with concrete. Figure 6 gives a good idea of these foundations.

Tower erection.—The individual towers are made up of 26 panels, panel points A to Z, inclusive, as shown in figure 2. They are triangular in plan, 820 feet high, 220 feet center to center of columns at base, 105 feet center to center of columns at panel point F, 215 feet above the base, and 9 feet 8½ inches center to center at the top, panel point Z. The tops of the foundations are about 12 feet above the surface of the ground, and above panel point Z there is a steel topmast 18 feet high, thus the extreme top of the steel is 850 feet above ground. The weight of each tower is substantially 560 tons.

The general scheme of erection devised by the Bureau of Yards and Docks and followed in the field contemplated erection to panel point G by means of an "erection tower" supporting three 120-foot steel booms, one for each leg of the main tower, stepped at panel point N. Each of these booms was provided with its own hoist, and since the program contemplated erection of the lower part of four towers and the upper part of four others simultaneously, it is obvious that very extensive erection gear was required. This equipment was designed and ordered by the bureau, at a cost of approximately $450,000. Its extent and cost were fully justified by the need for the most expeditious erection possible, and the expectation of speed was realized when tower erection began.

Panels J to P of each main tower were utilized as erection towers, being supported for this purpose on specially built concrete foundations. Figure 3 shows an erection tower in process of construction. The first two panels of the first erection towers were put in place by the steel gin pole provided as part of the erection equipment, the pole being supported on the ground during this operation; later on, when locomotive cranes were available, these two panels were erected by the cranes. The remaining panels were erected by the steel gin pole suspended and operated in the same manner as its subsequent use in the main tower; this was not only expeditious but useful in training the personnel in the use of the suspended gin pole. Figure 4 shows a completely erected and equipped erection tower in use in erecting the lower part of a main tower.

The scheme of erection contemplated the use of the gin pole alone from panel point G to the top, the length and weight of gin pole being reduced as the height of erected steel increased. This program was successfully carried out by the force that completed the erection of the towers when work was resumed after the armistice. Figure 5 gives a good idea of this phase of the erection.

Fig. 2.—Lafayette Radio Station. Individual tower with panel points indicated.

FIG. 3.—Lafayette Radio Station. Erection tower in process of construction.

Reference to figure 4 will show that the three main tower legs were supported during erection by guys. Although the trussed struts at panel point D were designed to take erection stresses in the absence of all guys, the guys were kept in place until the trussing at panel point F was erected, under which conditions the "portal" or lower 215 feet of the tower is fully self-supporting. Figure 4 shows the erection of the D-trusses in a single lift.

There was a great deal of difficulty experienced in making the necessary arrangements for the transportation of the fabricated structural steel and heavy erection equipment to Croix d'Hins from the point of discharge of vessels. This difficulty, though less accentuated, existed with respect to all materials brought to the station. The war had greatly depleted the rolling stock available, and the demands from the fighting front from time to time reduced cars to almost nil. Docking facilities were hard to get, as the port of Bordeaux is limited in this respect, and the requisite combination of docking facilities and transportation from dock to Croix d'Hins was very difficult to attain. It was only by dint of constant activity and frequent conferences with French and American officials, including a strenuous day spent among the offices of the various ministries at Paris, that dockage and cars were obtained and materials unloaded and shipped to Croix d'Hins, and this battle had to be fought practically every time a ship carrying radio material was due in port. The hazards of transatlantic transportation at this time are exemplified by the fact that one ship containing more than 1,000 tons of tower steel, or substantially 25 per cent of the total, comprising parts of seven of the eight towers, was narrowly missed by a torpedo fired by an enemy submarine off the west coast of France. If this torpedo had hit its mark, Armistice Day would have seen but little structural steel erected.

The erection-tower steel arrived at the station after a great deal of other steel had been delivered and sorted, and it was not until October 4, 1918, that the erection of the first erection tower began, but so thorough and complete was the preliminary work by the tower-erection force that erection of the main towers began early in November; towers 1 and 2 were completed to panel point F during the week ended December 7, 1918, and towers 3 and 4 to the same point during the week ended December 16.

Among the items of preliminary work referred to may be cited the completion of "dead-men" (nine per tower for all eight towers), the construction of engine houses and setting up of hoists, both steam and electric, the provision of electric power and compressed air at all parts of the work, the construction of an assembly and repair shop, served by two 6-ton stiff-leg steel derricks borrowed from the Army at Bassens, the construction of spur tracks to serve the site of each tower, and the construction of foundations for the erection towers for the first four towers.

A healthy spirit of competition was fostered among the gangs erecting the respective towers. No one was killed, and there were but one or two serious injuries. The rapidity and certainty of the erection is most complimentary to all concerned, but particularly to the designers in the bureau and the officers and men composing the tower-erection force. If this force had not been especially recruited for this particular work, there would have been a very different tale to tell.

November 11, 1918, found erection in progress on the first four main towers. The military necessity for early completion of the station having ceased to exist, it was decided to carry the erection of the first four towers to a point where they would be self-supporting in all conditions of weather, and to suspend erection pending further decision. Accordingly, towers 1 to 4, inclusive, were carried to panel point F, all loose erection gear was sent down and stowed,

and all made snug and secure until such time as erection should be resumed. The bulk of enlisted and enrolled personnel and most of the officers were returned to the United States in January, February, and March, 1919.

Post-armistice erection.[1]—Construction having been stopped, the French War Department, after some consideration, expressed its desire to have the work continued as an after-war project; but being unable to procure French labor sufficiently skilled in such work to insure speedy and economical completion, requested the United States Navy Department to complete the station for the French Government. With this request the United States Government complied and, on May 4, 1919, work was recommenced with the date of completion of the towers fixed as January 14, 1920. All work, with the exception of painting, which was delayed on account of rain, was completed on December 1, 1919, 44 days ahead of contract time. Figure 7 is a view of the completed project.

Camp and personnel notes.—The actual camp construction work was undertaken, all preliminary work and 25 per cent of steel erection completed prior to December, 1918, by enlisted personnel of the regular and reserve forces of the Navy. It is believed that never before has a project of such magnitude and unusual character been undertaken by any naval service, and the rapidity with which the work progressed and the excellent character of the work done remain a testimonial to the marked efficiency which the United States Navy had developed prior to the close of the Great War. When work was recommenced after the conclusion of the war, it was considered an injustice to the enlisted personnel of the Navy to expect it to continue the work at the enlisted rate of pay, especially as the military necessity for the station no longer remained, and, accordingly, the Navy Department let the completion of the work by contract to the Pittsburgh-Des Moines Steel Co. By the conditions of its contract the Navy Department furnished everything necessary for the work with the exception of labor. This included transportation of employees to and from France, food and housing for employees, office space, and all equipment and material.

It is interesting to note the accommodations furnished the workmen. Owing to the isolated location of the station and the belief that contentment spells efficiency, every effort was made by the naval authorities to take care of the men properly. The results obtained may well serve as an example for others engaged in similar work in a foreign country. Space in the Navy standard portable barracks, which are light and airy, well ventilated, and easily heated in winter, was provided at the rate of 500 cubic feet per man. A substantial iron cot with good springs, mattress, four sheets, and two pillow cases was given each man. Foremen were assigned to separate barracks with double space. Superintendents and office force were quartered in officers' barracks. Two medical officers and one dental officer were provided and furnished their services to all without charge. A dry canteen where Navy standard shoes and clothing (uniforms excepted), candles, sweets, tobacco, soap, and other necessary articles might be bought, was run by the Government without profit. A branch post office where money orders might be purchased was established. Excellent messes for foremen and workmen were maintained and run by the Government without cost to the employees. The food served was the Navy standard ration somewhat altered to meet the requirements of steel workers. These messes were models of cleanliness and were up to date in every respect. They were run on the cafeteria system and all modern culinary apparatus was provided to insure success. When it is realized that 400 men were served three

[1] The succeeding paragraphs relative to the Croix d'Hins project have been abstracted, by permission, from an article by Lieut. Commander D. Graham Copeland (C. E. C.), U. S. N. (resigned), published in United States Naval Institute Proceedings for December, 1920.

Fig. 4.—Lafayette Radio Station. Erection tower in service.

Fig. 5.—Lafayette Radio Station. Post-armistice erection, showing use of gin pole on upper panels of tower.

FIG. 6.—Lafayette Radio Station. Tower footings as designed by French engineers.

FIG. 7.—Lafayette Radio Station. Ensemble of completed towers.

times a day in less than 12 minutes per meal, it will be seen how thorough this detail was. There was scarcely ever a complaint received. The cost of the service to the Government was extremely low, averaging about 90 cents per man per day.

Owing to the prevalence throughout France of skin diseases, which are spread chiefly by hand laundries where all kinds of clothing are washed in the same tub or pool, it was found necessary to install a modern steam laundry to take care of the force's laundry. This was the only service for which the Government charged, but charges were just sufficient to cover cost of operation and replacement. From the start the laundry was well patronized, and its use soon caused an abrupt drop in the number of admissions to the sick list.

The design and general layout of this radio station were made under the cognizance of the Bureau of Engineering. The public works features, including the design and preparation of all plans for the towers, were carried out by the Bureau of Yards and Docks, under the direction of Commander E. C. Sherman (C. E. C.), U. S. N. R. F., project manager, and Mr. J. T. Maguire, assistant. The actual computations involved were made by Mr. A. E. Falconer, of the Bureau of Yards and Docks, who was in charge of the drafting squad who made the detail drawings.

The work at the site was begun under the administration of Lieut. Commander George C. Sweet, U. S. N. (retired), commanding officer, and under the personal supervision of Commander F. H. Cooke (C. E. C.), U. S. N., who completed the construction camp and about 25 per cent of the steel erection, Lieut. T. A. Baldwin (C. E. C.), U. S. N. R. F., being in charge of the tower-erection forces; and the work at the site was completed under the administration of Capt. A. St. Clair Smith, U. S. N., commanding officer, under the personal supervision of Lieut. Commander D. Graham Copeland (C. E. C.), U. S. N., officer in charge, and Lieut. A. C. Eberhard (C. E. C.), U. S. N., assistant. The construction work was handled for the Pittsburgh-Des Moines Steel Co., of Pittsburgh, contractors under the Navy Department, by Mr. H. W. Smith, superintendent, and Mr. Loyd Ellis, assistant superintendent.

CHAPTER XVII.

SUBMARINE BASES.

Previous to the outbreak of the World War and up to June, 1915, very little consideration had been given to the care and upkeep of submarines, except at the primary navy yards and stations. The crews were taken care of in mother ships, which provided sleeping accommodations and, to some extent, machine-shop equipment. Most of the repair jobs for submarines were done at the navy yards in shops provided for general purposes, the actual work being done either by members of the crew or by yard mechanics.

No consideration had been given to the establishing of bases for the maintenance of submarine detachments outside of the established navy yards, and until June, 1915, no comprehensive plan had been laid down for the accommodation of submarines in units.

In that month studies were undertaken by the Bureau of Yards and Docks with the view of developing a typical submarine base; that is, a base to be self-supporting as regards shop facilities, storage facilities, berthing for submarines, and barracks for crews and officers. A typical plan was developed for a unit of 10 boats. This plan contemplated the construction of two piers approximately 250 feet apart, with the idea of berthing two boats on each side of each pier, leaving space for a tender and sufficient space for increasing the number of submarines by triple banking to 18. The shore facilities consisted of a combination shop building, storehouse, barracks for crew, quarters for officers, towers for radio communication, fresh-water and fuel supply, a small magazine for small-arms ammunition. The piers were arranged in two ways, one perpendicular to the shore line for locations where the current was not too swift to interfere with submarines berthed alongside the pier, and another arrangement with the piers parallel to the shore line for locations where the contrary situation was encountered.

Considerable study was given to the arrangement of piers, shops, etc., and the resulting layouts embody the following features:

The piers were designed of concrete, supported on concrete piles, and equipped with large outlets for submarine storage batteries, and also with high-power compressed air for charging torpedoes inside

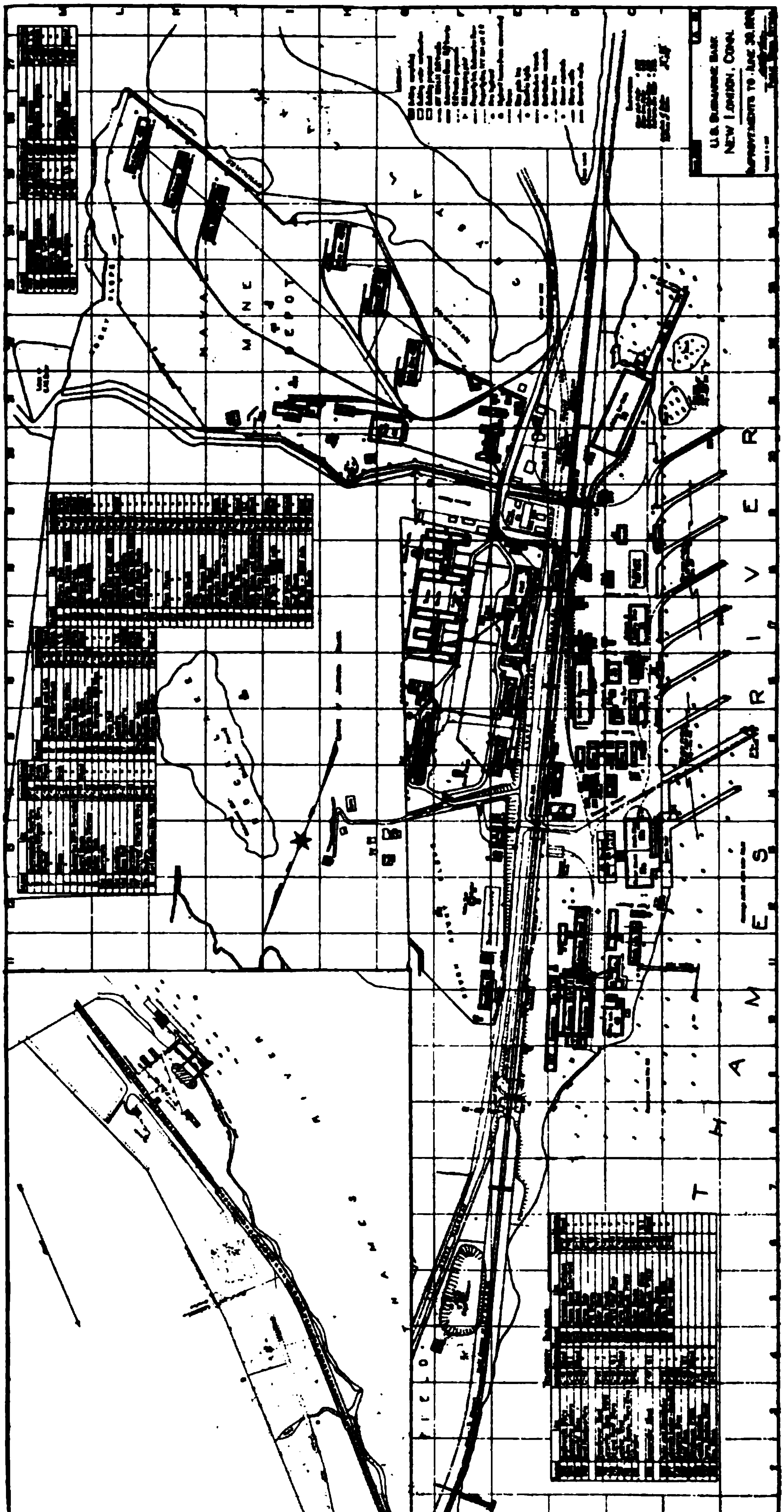
the submarines. The shop building, which was shaped in the form of the letter U, comprised a machine shop for light work, a small foundry, a blacksmith shop, and a pattern and woodworking shop in the main portion of the building; in one wing a torpedo and gyro testing room, with the necessary compressors and accumulators; and in another wing a substation with the necessary motor-generators for converting current to 110 volts direct current for submarine batteries. This building was to be located immediately inshore from the piers, so as to be readily accessible for repair work.

Adjoining the shop building, but separated by the width of a street, was located the storehouse. This building consisted of a two-story building, affording accommodations for the storage of torpedoes, small parts, and miscellaneous materials, with individual rooms for the storage of parts belonging to each submarine assigned to the station. This building was to be equipped with a traveling crane for handling torpedoes in and out of racks and on to trucks for delivery to the water front. Sufficient space was left behind the storehouse and shops for additional facilities of the same kind.

A barracks building to accommodate 350 men was designed, to be located immediately back of the shop buildings. This was of two stories, and contained sleeping accommodations, mess hall, and recreational features for 350 men. The Bureau of Navigation stated at that time that a submarine base for 10 submarines would require accommodations for 600 men and 80 officers. This would make necessary the construction of two buildings for crews as outlined above. The building for officers was designed to accommodate 43 officers in individual rooms, with facilities on the first floor for messing and recreation, and also contained offices for the flotilla commander, officer of the day, and the necessary clerical force for the administration of the base. In addition to this there was provided a radio installation for communication, crematory for disposal of station waste, elevated water tank for fresh-water supply, and storage tanks for fuel. These, with the necessary underground distributing systems, made up a complete unit for the basing of 10 submarines.

Pearl Harbor.—The first modification of the typical plan was made for Pearl Harbor, where the arrangement of piers was somewhat changed, in that the spacing was changed to 75 feet clear between piers, it being then the policy of Operations that submarines should not be double banked. This made necessary the construction of more piers of a smaller character, one pier only being designed for railroad track and other facilities, although all piers were designed with units for charging submarine batteries. A special feature was provided on the outer end of the charging pier for lifting the tails of submarines clear of the water for propeller and rudder adjust-

Panorama of Submarine Base, New London, Conn.



Plan of Submarine Base, New London, Conn.

ments. This consisted of a crane of 30-ton capacity at a reach of 13 feet clear of the fender system, the crane having a less capacity at greater reach.

Very little change was made in the quarters accommodations, except that all were designed for tropical conditions.

The layouts for the typical base were approved by the chief of the bureau in September, 1915, and certain modifications were approved in May, 1916, which modifications involve the providing of additional cubic space for men in the barracks buildings. The tentative layout for the Pearl Harbor base was approved by the chief on December 28, 1915, with modifications recommended by Navigation, which modifications received the chief's approval on May 18, 1916.

The particular location selected was Quarry Point. An allotment was made in March, 1917, for the construction of a creosoted-timber pier at Quarry Point, this marking the beginning of the submarine development at Pearl Harbor. Since that time one additional creosoted-timber pier and a barracks building inshore have been constructed. No shop facilities of a permanent nature or housing have been attempted up to the present time, although a complete layout for a submarine base of 24-boat capacity has been designed and approved by the Board for the Development of Navy Yard Plans.

New London.—The first continental location selected for a submarine base was New London, Conn. The improvements at the New London naval station which existed prior to March, 1917, were used as a basis for the development of a submarine base, and the naval appropriation act of March 4, 1917, contained an item of $1,250,000 for the erection and equipping of repair shops, quarters for men and officers, and berthing space for submarines. This appropriation was expended toward the development of the water front, the enlarging of existing structures, and the erection of new structures for shop, storage, housing, and all other features allied to a submarine base.

The improvements existing at the beginning of the development of the base were: A wharf running parallel to the shore line, approximately 600 feet long, which was used as a coaling wharf, a large portion of the shed and deck of which were destroyed by fire previous to the beginning of the development; a coal shed immediately inshore of the wharf; two small brick structures used as storehouses; a brick building used for marine barracks; a steel coal shed; and a 100,000-gallon steel water tank. No other improvements were on the property at that time.

The old coal shed was converted into a machine shop and power house, and the quay wall inside the wharf was used for a beginning of submarine berthing space. Eight finger-piers, 275 feet long by 20

feet wide were constructed at an angle of 30° with the water front, the water front being a continuation of the existing quay wall. One pier 350 feet long by 35 feet wide, and having on the outboard end a 30-ton crane for lifting the tail ends of submarines, was constructed to the south of the main machine shop. The finger piers were located with a clear distance between of 125 feet.

Buildings were constructed ashore as follows: A general storehouse, torpedo storehouse and shop, battery overhaul, mechanical laboratory, garage, engine laboratory, individual storerooms, and various other smaller units for base activities.

The housing development consisted of two barracks buildings for 500 men each, mess hall for 1,000 men, dispensary, quarters for student officers, quarters for submarine officers, submarine school, an extension of the old marine barracks for housing 750 men, a clubhouse, a bench school, and a recreation building.

The New London site was also utilized for a mine and ordnance depot, as discussed in another chapter.

Coco Solo, Panama.—The necessity for a submarine base at the Panama Canal was realized, and early in 1917 the War Department was asked for a site on the Atlantic side. The War Department designated Coco Solo Point as being best suited for submarine activities. A preliminary estimate for the construction of a base was submitted to the Secretary of the Navy on May 25, 1917. This estimate was $741,025 for the construction of a submarine base, consisting of dredging, concrete wharf, finger-piers, electrical work, storehouse, and miscellaneous construction. The construction of the base was proceeded with, and at the present time there is located in Panama a complete base for the maintenance and upkeep of 20 submarines.

The development consisted of the construction of a basin inclosed by quay walls, four piers being constructed at right angles to the innermost wall, about which wall were also constructed the station buildings and accommodations for submarine crews and officers. Immediately to the rear of the buildings and housing development there was constructed the fuel-oil and gasoline storage for the station. Immediately adjoining the submarine base to the south there was constructed the air station, a description of which is to be found under the title "Shore facilities for aviation." All the buildings were of the tropical type and follow the designs, types of which are shown in accompanying illustrations.

Philadelphia, Pa.—At the navy yard, Philadelphia, in order that submarines might be separated from the station proper, Pier D in the back basin was assigned to submarine activities, and on this pier were constructed submarine charging facilities and a small machine shop. The pier was also equipped with facilities for berthing sub-

Battery-overhaul building, Submarine Base, New London, Conn.

Industrial group, Submarine Base, New London, Conn.

Torpedo shop, Submarine Base, New London, Conn.

Shore accommodations for submarine crews, Submarine Base, New London, Conn.

Typical barracks for 500 men, Submarine Base, New London, Conn.

Officers' quarters, Submarine Base, New London, Conn.

marines on each side. This pier was of the filled-in type, and had a depth of water of 30 feet on either side. Electric current, fresh water, and other services were obtained from the yard supply.

West coast.—The Commission on Navy Yards and Naval Stations, of which Rear Admiral J. M. Helm, U. S. N., was senior member, reported on January 3, 1917, that this commission had investigated the west coast of the United States, and that the following sites were recommended for submarine bases:

Ediz Hook, near Port Angeles, Wash.
Tongue Point, near Astoria, Oreg.
Los Angeles, Calif. (San Pedro).

Additional facilities at the Puget Sound and Mare Island navy yards were recommended, but the Puget Sound undertaking was later abandoned. Appropriations were obtained only in the last naval bill (1920) for the initial development of Tongue Point.

Mare Island.—A beginning was made on the Mare Island base in the latter part of 1917, comprising an L-shaped pier with a storage-battery charging and repair station located at the inshore end. This station being situated on tule-lands necessitated the use of pile foundations, and also the construction of a trestle for carrying the roadway and railroad tracks from the submarine base to the yard proper. All facilities for service were connected to the main yard systems and all repair work was done in the yard shops.

Hampton Roads.—When the naval operating base at Hampton Roads was first conceived a section was devoted to submarine-base activities. This section was laid out at the extreme northeast corner of the property and sufficient land was reserved immediately inshore from the north and west boundary lines for the development of the submarine base to accommodate 20 boats.

The base as laid out consisted of an inclosed basin approximately 1,100 feet wide by 1,200 feet long, with a dredged depth of 25 feet at mean low water. The inclosing structures consisted of a creosoted sheet-pile platform bulkhead on the north and west sides, served by railroad tracks, and a pier 1,300 feet long by 120 feet wide, with a sheet-pile bulkhead on the basin side for protection against wave action from the southwest. An opening was left at the extreme northwest corner, 150 feet wide, for ingress and egress of submarines and destroyers. Ten finger-piers, 330 feet long by 18 feet wide, with a clear distance between of 75 feet were constructed at right angles to the bulkhead, the spacing of 75 feet being adopted upon the recommendation of Operations that submarines be not double banked.

The original design called for dolphins, four in number, to be placed in the center of each slip so that there would be no possibility

Seaplane view of Submarine Base and Air Station, Coco Solo, C. Z.

Typical tropical barracks for 200 men, Submarine Base, Coco Solo, C. Z.

Executive officer's quarters, Submarine Base, Coco Solo, C. Z.

Construction of pier at south of submarine basin, Naval Operating Base, Hampton Roads, Va.

of submarines coming in contact with each other. These dolphins were later omitted, so that in case of necessity an additional submarine could be berthed between the boats lying at the piers.

The inclosing bulkheads and pier were designed for the accommodation of destroyers. All of the piers are equipped with railroad tracks and are designed for carrying a 15-ton standard locomotive crane. They are of timber construction on creosoted piles, and are built at an elevation of 10 feet above mean low water.

The shore structures consist of a torpedo-storage and administration building, battery storage, a machine shop, a storehouse, a boiler house, a subcharging and compressor station, and two compressor buildings. All of these buildings are of permanent construction, and are interconnected by a railroad track system, which tracks, running parallel with the water front, connect the submarine base to the main station. The entire shore plant is constructed on made land, and in the early stages of construction it was necessary to build a corduroy road from the main base to the submarine base for the transportation of construction material. Sufficient space was left immediately east of the buildings enumerated above for future extension of industrial activities.

There has been laid out a housing development, consisting of barracks buildings and mess hall for crews, and quarters for bachelor and married officers. The construction of these, however, has not been undertaken up to the present time, accommodations for submarine crews having been constructed in the form of temporary wooden barracks buildings fronting on the bulkhead along the extreme northern boundary line of the station.

By berthing submarines three to a slip the capacity of the base can be increased by 11, making a total berthing capacity at the piers of 31. This can be increased to a still greater capacity by berthing submarines at the inclosing bulkheads and on the inside of the 120-foot pier.

The weather conditions in Hampton Roads made it absolutely necessary to provide an inclosed basin, and even with the protection afforded by the inclosing bulkheads, the basin in extremely rough weather is chopped to such an extent that submarines do not lie as quietly at the piers as is desirable.

Key West.—The Commission on Navy Yards and Naval Stations, in their report on the south coast of the United States, recommended that a submarine, destroyer, and small-boat base be established at Key West. Work at this point is now in course of construction, consisting of piers and breakwater for berthing submarines. This project was not actually inaugurated, however, until after the armistice.

It will be seen from the foregoing that the undertaking of caring for submarines and their crews has grown from a very small beginning, in 1915, to an elaborate program now existing and planned for the near future. The activities of the past war have shown that the submarine arm of the naval service is one that must be kept to its maximum efficiency, and the keeping of the morale of the crews at a high level makes necessary the provision of recreational and housing facilities ashore, so that they may have facilities for relaxation from their strenuous duties while engaged in submarine service.

CHAPTER XVIII.

SHORE FACILITIES FOR AVIATION.

Fixed land bases for naval aviation, so far as concerns the United States, had their beginning at Pensacola, Fla., in 1914. Early in 1913 the first mobile naval aviation camp had been established at Annapolis. During the same winter a second camp was inaugurated at Guantanamo, Cuba. In those days and for some time beyond, aviation camps were essentially different in character from the naval air stations of to-day. Then a few portable tents, a good beach, and a sheltered body of water, usually with the cooperation of a naval vessel specially detailed, comprised the entire equipment. Two or three planes, with a makeshift machine shop, made up the matériel, and an instructor, a student or two, and a couple of mechanics formed the personnel.

It is perhaps not generally understood that as late as 1917 all plans revolving about the central idea of sea flights as distinguished from those over land were necessarily premised on the use of warships as mother vessels. It was the accepted notion that the usefulness of aeroplane flights over water, so far as they related to naval possibilities, was limited by the extent to which they could cooperate and keep in contact with the units of the fleet. During the active operations of seaplanes in the theater of war this original theory was very largely modified. Motor improvements, amplification of effective radius of operation due to increased fuel capacity, and the satisfactory construction of comparatively seaworthy hulls had not a little to do with this variation of the initial concept of seaplane usefulness.[1]

This change of view, whether or not destined now to be final, had an immediate bearing on the activities of the Bureau of Yards and Docks from the outset of American participation in the war. In April, 1917, the only naval air station in the country was that at Pensacola. Its facilities, though efficient, were limited, consisting of three seaplane hangars of steel construction, a brick structure used as a hangar, an airship shed mounted on a barge (capable of accommodating a small type of nonrigid craft), and a few service buildings.

[1] The foregoing is abstracted at large from article "Naval Aviation," by Ensign Thos. F. Woods, U. S. N. R. F., in Army and Navy Register of May 31, 1919.

WAR CONSTRUCTION IN THE UNITED STATES.

Original patrol stations.—Upon the declaration of war the possibility of submarine depredations and the effectiveness of air patrols as a protective measure led to conferences looking to the immediate establishment of air-patrol stations at strategic points, particualrly on the Atlantic coast. Prior to this time a program of construction to accommodate lighter-than-air craft had been formulated, and this took definite shape with the placing of a contract, dated April 18, 1917, for the fabrication of the steelwork for eight airship hangars and the erection of seven of the same at points to be designated. The dimensions of these early hangars were approximately: Length, 250 feet; breadth at ground, 133 feet; overhead clearance, 66 feet. They were designed on the three-hinged arch principle, with 12 arch ribs for each completed hangar. Contract for the two-leaved doors was let separately. Steelwork for the structures proper averaged about 320 tons each, and for the doors approximately 50 tons. Payment was made on tonnage erected, and the final cost under both contracts was in the neighborhood of $375,000, exclusive of foundations and covering.

With the above work under way, development of plans and awarding of contracts for the projected coastal air stations was undertaken in the earliest days of American hostilities. A typical installation was decided upon and contracts were let on the cost-plus basis for the purpose of gaining the speediest possible completion, costs to be defrayed from the appropriation "Aviation, Navy," of August 29, 1916, amounting to $3,500,000. One of the dirigible hangars already being fabricated was intended as an element of each patrol station.

The new stations developed will be described in a general way, following the chronological order of their establishment.

Montauk, Bay Shore, and Rockaway Beach, distributed along the southern shore of Long Island, were chosen as sites under the first contract awarded. This contract was signed on June 14, 1917, and flying patrols were being operated from Montauk and Rockaway early in the autumn of that year. The following facilities were provided at each of these two bases: 1 dirigible hangar, as previously mentioned; 1 steel-framed seaplane hangar; 1 shelter for hydrogen-generating plant; 1 shop; 1 storehouse; 1 truck shed and power house; 1 pier and boathouse; 1 seaplane pier; 1 officers' quarters; 2 men's quarters; 1 mess and recreation building; and all necessary accessory structures, together with requisite roads, water supply, sewerage, drainage, grading, heating, lighting, and other services necessary to utility and habitability. Thus all needs of personnel and plant operation, so far as could be foreseen, had to be taken care of at the outset, although at

Seaplane view of Naval Air Station, Rockaway, L. I.

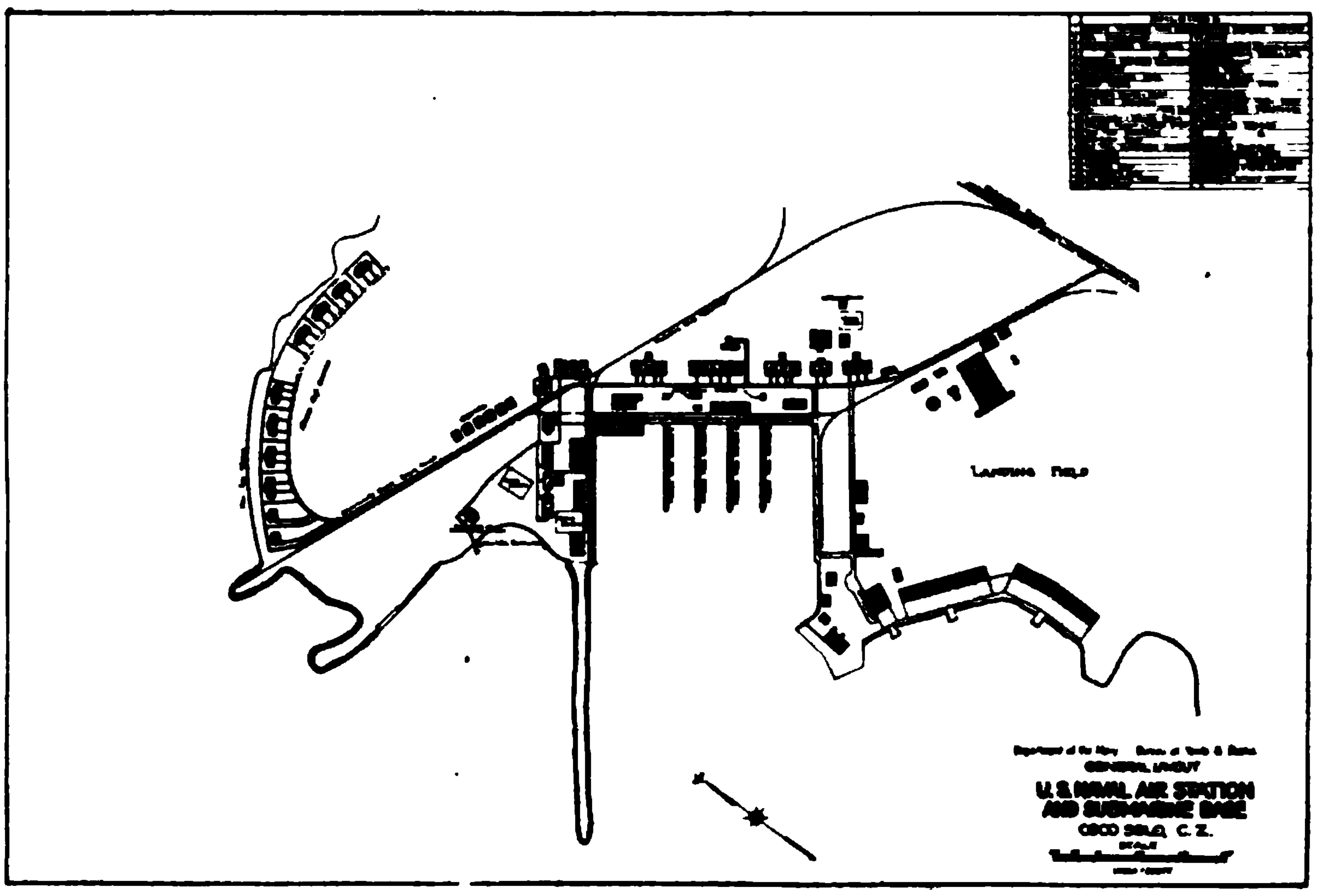
Seaplane view of Naval Air Station, Cape May, N. J.

Seaplane view of Naval Air Station, Hampton Roads, Va.

Seaplane view of Naval Air Station, Key West, Fla.

first sight nothing would appear simpler than the mere proposition of setting up a seaplane hangar and an airship shed.

The work at Bay Shore was executed to the same specification as the foregoing, with the omission of the airship hangar and hydrogen facilities. A further contract, dated September 28, 1917, was awarded for the construction of a timber seaplane hangar at Bay Shore, at a cost of $13,000. This structure, built to house three planes, was the earliest hangar of its type erected by the bureau, the roof span being carried on wooden trusses instead of steel. This departure was an emergency measure due to the increasing shortage of steel as the war progressed, and was utilized in naval aviation construction abroad in a standardized form.



Plan of Naval Air Station, Coco Solo, C. Z.

At Cape May, N. J., a coastal air station was built under a contract dated August 16, 1917. This contract was completed early in 1918 at a cost of approximately $500,000, and provided facilities similar in all respects to those at Montauk and Rockaway, one of the steel dirigible hangars aforementioned being located at this point.

Key West, under a similar contract, followed on August 24, 1917; Chatham, Mass., on September 8; Hampton Roads at about the same time, being allotted one of the steel dirigible hangars, runways, and four wooden seaplane hangars. The coastal stations at Coco Solo, Canal Zone, and San Diego, Calif., complete the list of the first eight patrol bases contemplated as a war measure.

The construction of the station at Chatham, on Cape Cod, presented some major difficulties which are worthy of mention. In the first place, the work was performed during the winter months of 1917–18,

and the winter will long be remembered as a particularly severe one. Again, the site of the station was 5 miles distant from the nearest freight station (Chatham), and the roads were in very poor condition for hauling the heavy steel sections for the hangar and the other building materials. There was no local labor to speak of, necessitating the importation and housing of the workmen. Another difficulty encountered was the total absence of a suitable water supply on the premises, the water having a hardness content of nearly 75. The wells which had been driven were abandoned and a pipe line was run to a lake some 10,000 feet away.

An elaborate and expensive sewage system had to be designed and installed because the State board of health would not permit the emptying of raw sewage into the surrounding waters for fear of polluting the oyster beds which completely surround the station. Septic and dosing tanks were constructed with an automatic siphon to discharge the effluent to a sand filter bed. It was further necessary to make these filter beds of the subsurface type because of their proximity to the buildings, this being necessitated by the topography of the land and the nature of the soil. The firm of Metcalf & Eddy, Boston, sanitary engineers, were consulted in the matter and approved of the designs of the civil engineer officer in charge.

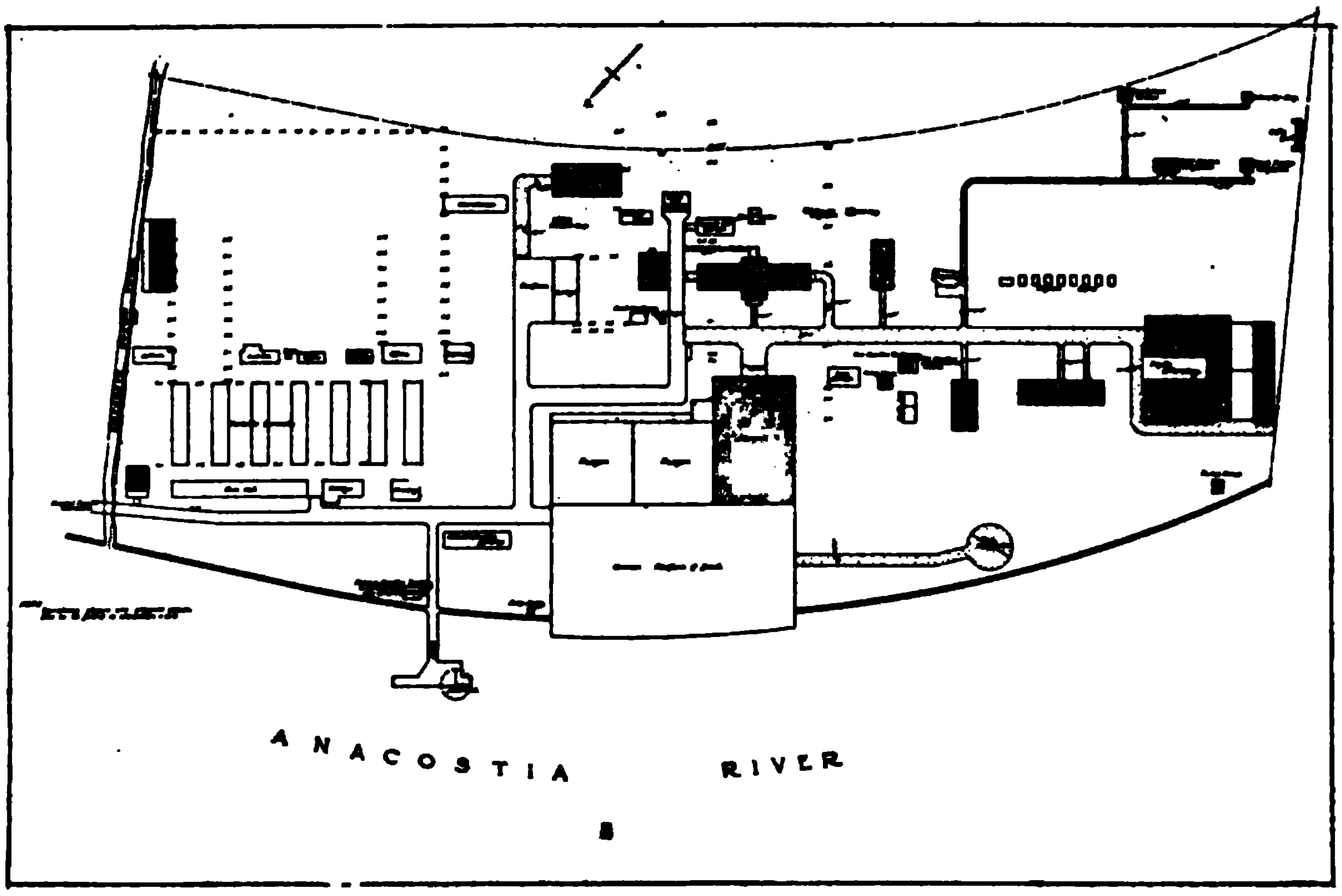
The contract covering this operation was of the "cost-plus" variety and required that the contractor furnish detailed designs for all the services, such as sewage disposal, heating, and water supply. The contractor had no organization equipped to do this, and in order to get the job done at all the civil engineer officer had to do practically all the designing himself.

The scheme of improvements originally planned for the coastal air stations would have entailed an expenditure, according to bureau estimates, of approximately $300,000 each. The first contracts executed, however, largely overran this figure, and the naval aviation program continually expanded with the progress of the work. Complete new stations were called for at various points during 1918, and the first survey of the situation became a mere detail of a tenfold greater development.

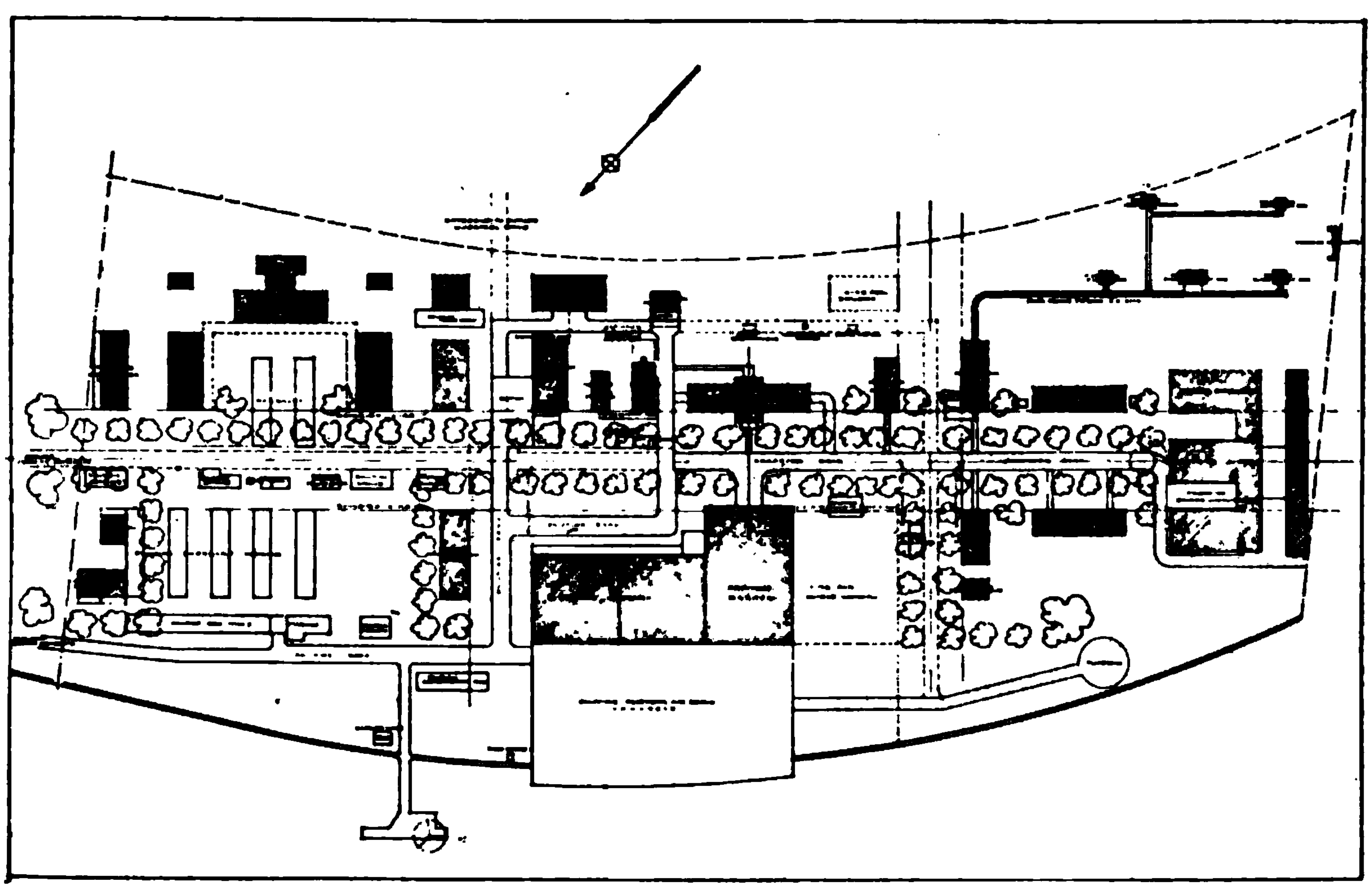
As illustrating the increase of demands for land facilities, it may be noted that the single station at San Diego has cost more than the amount estimated for the original eight; instead of 120 men as originally contemplated, facilities were provided for as many as 1,200 men at individual stations; and instead of one small hangar there were placed as many as 15 units of a considerably larger type.

Supplementary patrol and training program.—As naval participation in the war progressed and the functions of aviation as an adjunct of operations became more clearly defined, much heavier demands were made for traning facilities for student aviators at ex-

isting stations. It was also found expedient to provide a greater number of coastal patrols, both as a war measure and for the training features afforded.



Existing plan of Naval Air Station, Anacostia, D. C., showing temporary buildings.



Permanent plan for Naval Air Station, Anacostia, D. C.

Dealing first with the additional stations undertaken during the war, these establishments may be noted by location, as follows:

Anacostia, D. C.
Morehead City, N. C.
Brunswick, Ga.
Miami, Fla.
Marine flying field, Miami, Fla.
Akron, Ohio (for lighter-than-air craft).

Schools for flyers, groundmen, mechanics, etc., were established at the following points:

Hampton Roads, Va.
Pensacola, Fla.
Santa Rosa, Fla.
Charleston, S. C.
Great Lakes, Ill.
Dunwoody Institute, Minneapolis.
Seattle, Wash.
San Diego, Calif.
Cambridge, Mass.

It is to be noted that several of these schools were placed in connection with regularly operating stations.

Rest stations were established as follows:

Waretown, N. J.
Assateague, Va.
Beaufort, N. C.
Charleston, S. C.
Roanoke Island, N. C.
St. Augustine, Fla.
Tampa, Fla.
Indian Pass, Fla.
Isla Morada, Fla.

The rest stations consisted, in general, of a small landing beach and a supply of gasoline and oil. No repair facilities were afforded. The location of these stations was approximately midway between the larger establishments.

Kite-ballon hangars were erected at certain of the established stations, and separate projects of this character were undertaken at Marginal Parkway (Brooklyn) and Charleston, S. C.

Before the close of the war, development of the following stations was under way:

Marine flying field, Quantico, Va.
Marine flying field, Parris Island, S. C.
Naval air station, Yorktown, Va.
Naval air station, Galveston, Tex.

As a typical case of the growth of naval aviation up to the very close of the war, the circumstances surrounding the establishment of the station at Brunswick, Ga., may be cited. On October 5, 1918, the Chief of Naval Operations addressed the following circular letter to all bureaus:

OCTOBER 5, 1918.

Subject: Equipment for naval air station at Brunswick, Ga.

1. The establishment of a naval air station at Brunswick, Ga., has recently been authorized. While it is the intention of the department ultimately to convert this station into a 12-seaplane patrol station, it will be originally established as a 2-squadron training station on account of the present urgent need for increased training facilities. The bureaus are requested to furnish material necessary to operate a 2-squadron preliminary training seaplane station, composed as follows:

18 tractor type.
12 F-boats.
6 HS type.

2. It is desired that this material be prepared and shipped at the earliest date practicable.

3. It is requested that a copy of the lists of all material ordered for this station be furnished this office.

G. W. STEELE, Jr.,
By direction.

Seaplane hangar, Cape May, N. J., straight-truss type.

Seaplane hangars, Hampton Roads, Va.; straight-truss, rolling-door type.

Seaplane hangars, Hampton Roads, Va.; curve-truss, sliding-door type.

Seaplane hangars, Cape May, N. J.; curve-truss, sliding-door type.

The work executed by the Bureau of Yards and Docks under this order proceeded at high speed, a standardized installation of portable buildings having been developed for such uses both at home and abroad. Material requirements were taken care of by requisition, and the formalities of a public-works contract were dispensed with.

The structures required were 20 buildings for barracks and officers' quarters, 6 seaplane hangars, 3 kite-balloon hangars, a pier, a heating and power plant, 3 storehouses 60 by 40 feet, 2 storehouses 20 by 70 feet, 2 administration buildings, one shop 20 by 110 feet, a mess hall for 600 men, a garage, oil storehouse, dispensary, concrete landing platform, timber seaplane runway, roads, sewers, etc.

On November 13, 1918, two days after the armistice and less than six weeks after the inception of the project, Lieut. R. L. Pettigrew, the public works officer, was able to make the report to the bureau from which the following paragraph is extracted:

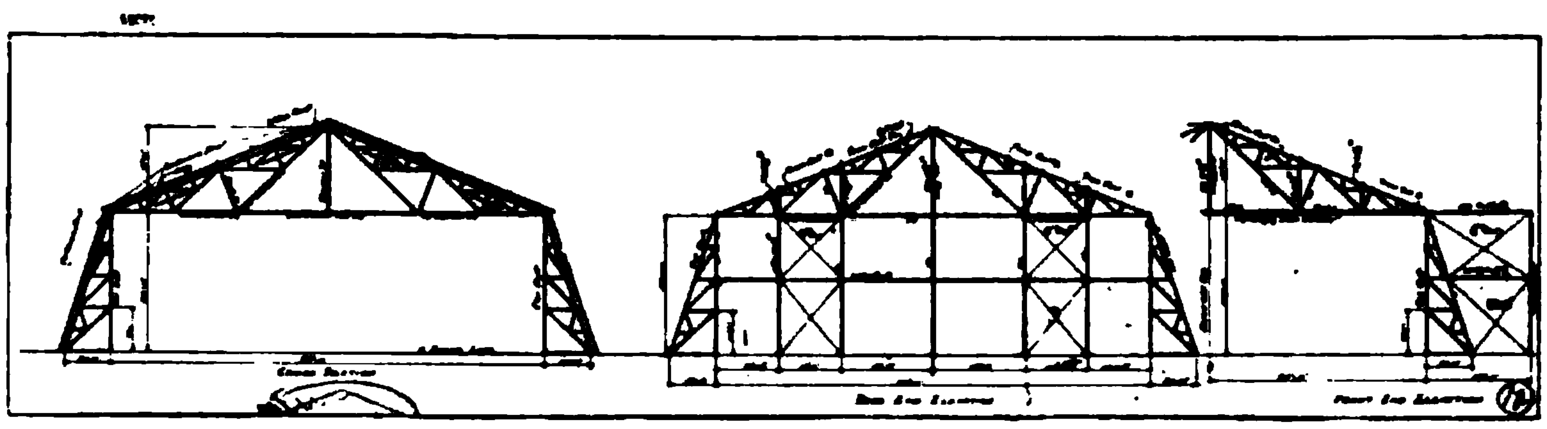
> Five buildings are now complete except for the electric wiring. Ten more are complete except for the roofing, which is being rapidly put on. Foundation posts are in for 12 more. The floors and foundations have been poured for the three 60 by 40 foot storehouses, and concreting was started to-day on the platform in front of the hangars. After conference with the commanding officer several days ago it was decided to order six airplanes for delivery by December 1. A complete hangar will probably reach here by December 8, in which event it will be erected by about December 15. It is expected to start the runway into the water as fast as the material arrives.

Very little construction work at Brunswick was done after the above date, and the station was closed and property liquidated a year later.

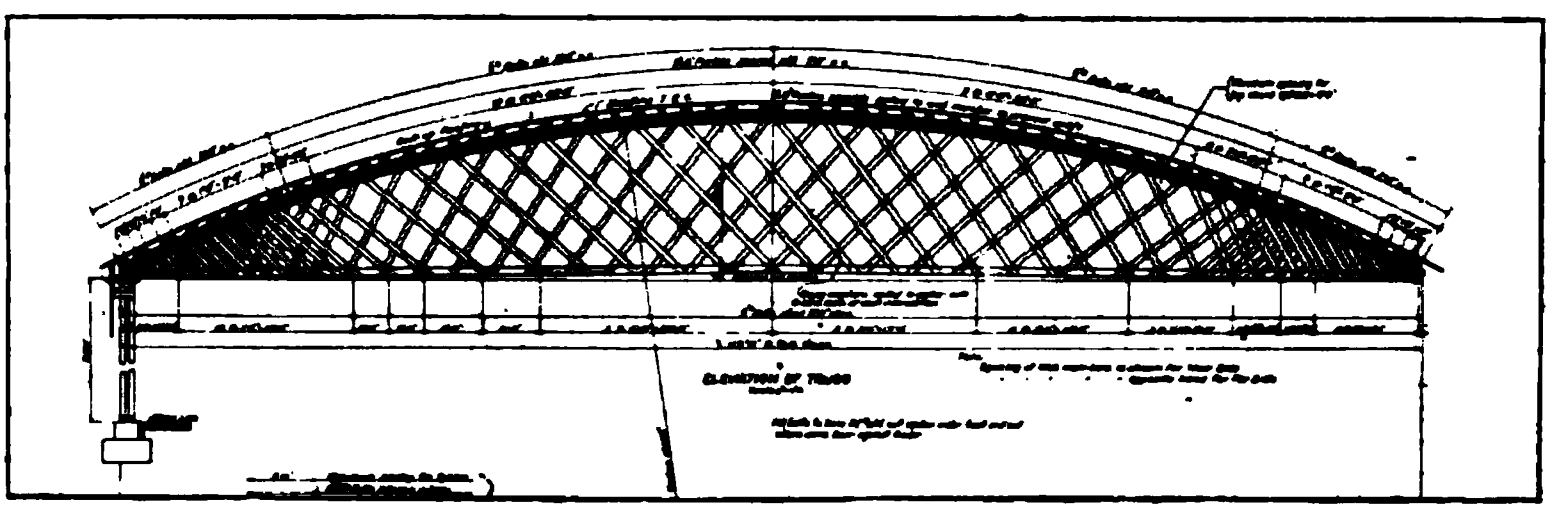
Returning to the subject of expansions effected at the patrol stations subsequent to their establishment, only a few salient details need be presented. From an original estimated personnel of approximately 1,000, the home naval aviation force, active or in training, which had to be housed, rose to 15,000, as many as 5,000 men being quartered at Pensacola at one time during the war. The Montauk station comprised 49 separate buildings at the time of the armistice, and construction expenditures at that place had reached approximately $1,500,000 instead of the $300,000 originally estimated. At Cape May, Key West, and elsewhere the same conditions were essentially repeated. The character of improvements effected at Chatham, Montauk, Rockaway, Bay Shore, Cape May, Anacostia, Hampton Roads, Miami, Key West, and Coco Solo can be inferred from a general summary of facilities placed. Not every class of building here mentioned would be found at each station; still, the distribution of the following structures was quite general: Hangars, carpenter shops, machine shops, dope and paint shops, storehouses, beaches and piers, marine railways, boathouses, observation towers, motor test stands, oil-storage and reclaiming plants, gasoline storage, garages, fences, gas holders, hydrogen generator plants, fabric storehouses and shops,

cylinder storehouses, laboratory and compressor buildings, blower houses, administration buildings, barracks, mess halls, officers' quarters, photographic laboratories, guardhouses, dispensaries, etc. Services supplied included roads, walks, sewers, heating, lighting, water, and telephones.

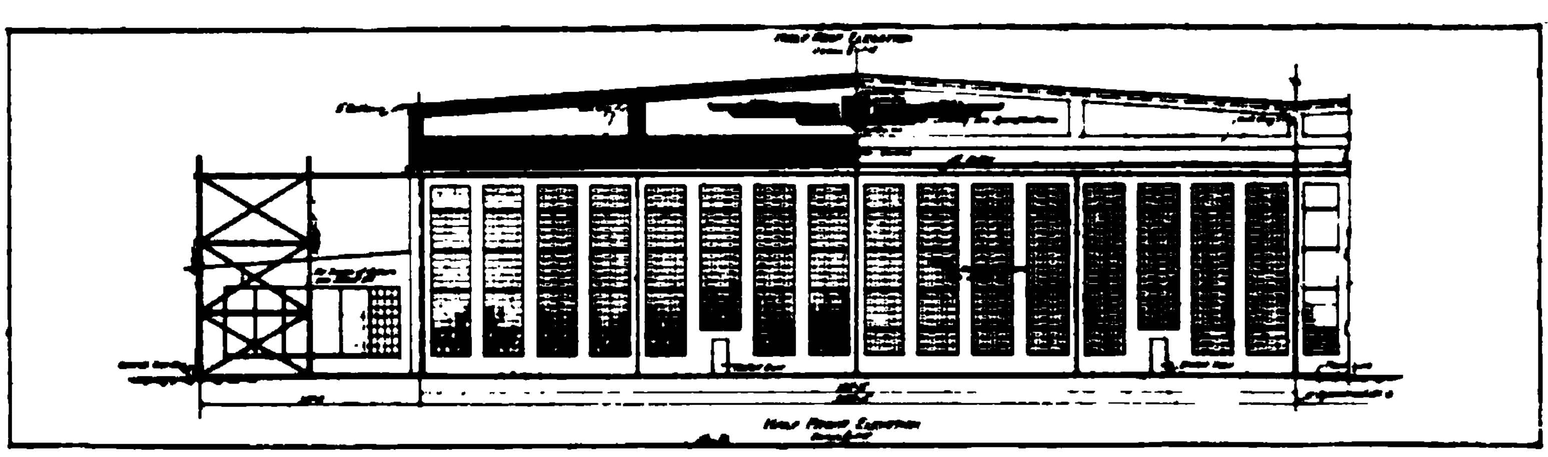
Cost.—It may be mentioned at this point that the cost of the naval aviation shore-construction program grew, before the end of the war,



Details of seaplane-hangar framing, straight-truss, 75-foot span.



Elevation of standard curve truss, 112-foot span, for seaplane hangar.



Elevation of standard 151-foot seaplane hangar.

from the $2,400,000 originally estimated to more than $30,000,000, at home and abroad.

Stations closed since the war.—Further construction was suspended at the following stations after the armistice, and the stations have been closed:

Montauk, L. I.	Miami, Fla.
Bay Shore, L. I.	Marine flying field, Miami, Fla.
Marginal Parkway, N. Y.	Key West, Fla.
Morehead City, N. C.	Akron, Ohio.
Brunswick, Ga.	Galveston, Tex.

Typical dirigible hangar, Cape May, N. J.

Kite-balloon hangar, Hampton Roads, Va.

Barracks and mess-hall, Naval Air Station, Hampton Roads, Va.

Barracks and mess-hall, Naval Air Station, Hampton Roads, Va.; view of court.

Barracks for 200 men, Naval Air Station, Cape May, N. J.

Rest stations at all points were closed.

Schools were closed as follows:

Santa Rosa, Fla.
Charleston, S. C.
Dunwoody Institute, Minneapolis.
Seattle, Wash.
Cambridge, Mass.

Permanent training stations.—Two stations have been reserved permanently for the training of naval aviators located at the points judged most favorable from climatic and other viewpoints—Pensacola, Fla., serving the eastern seaboard, and San Diego serving the west. The greater part of the work at the latter station is a post-war development, but the installations at both places will be briefly described as indicating the present-day conception of proper training facilities for the Navy's flyers.

The Pensacola air station, as previously stated, accommodated approximately 5,000 men at the height of its activity, more than 150 seaplanes having been in use there for training purposes. The peace-time complement of the station is now placed at 2,000 men. Practically all of the "emergency" construction at Pensacola is still available for use under proper maintenance, being of semipermanent type. In appearance the buildings make no architectural pretension, but their purpose has, in general, been satisfactorily served both during and since the war.

The Pensacola naval station was established as long ago as 1828, but for many years had remained in a state of suspended activity. The advent of aviation has now displaced practically all other operations at this yard, existing buildings having been adapted to aviation needs and many new ones built.

As the station now stands there are 11 large seaplane hangars of multiple-unit construction, and 8 smaller ones, all provided with suitable piers and concrete beaches. East of these hangars are located the seaplane erecting shop with its extension, a machine shop, and a large wet-basin leading in to the boat shed. Next to the basin stands the 200-foot steel observation tower. The eastern water front is served with quays, a 600-foot pier, and a sea wall.

Within the old station wall are placed 80 or more buildings serving the various needs of the establishment, such as four large mess halls, barracks, a bakery, schools, storehouses and shops of all kinds, offices, a hydrogen plant, laundry, recreation buildings, gymnasium, officers' quarters, etc.

To the north of this section is located the airship field with its two hangars and storehouse, and a commodious drill ground.

The station as a whole, though developed under great pressure, is well arranged for its requirements, and the facilities and climatic conditions to be found there make it the logical center for naval aviation training on the east coast.

At San Diego, Calif., the air station has been developed as a feature of the program which is to make this city a base for every phase of naval training and operations. Construction at all points on San Diego Bay is being executed in permanent materials and to a unified architectural style.

The air station is located on the north point of North Island, within the bay. Its permanent facilities represent largely a postwar development, though plans were prepared and the first large contract was let several months before the armistice.

Accommodations are now provided for 1,000 student aviators and 50 officers, with hangar and shop facilities for 20 or more seaplanes, 1 airship, and 2 kite-balloons. The plans for the station as a whole are practically realized, and the architectural finish and arrangement of the group are most satisfactory. Roads, grounds, and services are complete, and the only contract now under way is to provide three supplementary hangars and an aeronautical storehouse.

The station map inserted will give an idea of the symmetry and compactness of the layout, permanent construction being represented by the shaded areas. Quarters, shops, and administration buildings are rendered in the Mission style, as the purpose has been to make all the naval establishments at San Diego conserve the ends of taste as well as of utility.

The type of construction at the air station is illustrated by the specification requirements for the administration building. This structure of two stories and 125-foot entrance tower is 345 feet long over all, with a general width of 40 feet and a maximum of 83 feet through its pavilions. Its structural framework is of reinforced concrete; the exterior walls are of hollow terra-cotta tile or concrete, with cast-stone sill work and trim; an effective use of red tile roofing is made; the interior walls are of hollow terra-cotta tile; sheet-metal work is of copper; floors are of composition or terrazzo finish; doors and sash are of steel; stairways and balustrades are of plain and ornamental iron or steel; exterior finish over all, buff-colored stucco, troweled in an irregular wavy pattern to simulate the weathered effect of local specimens of Spanish Mission architecture.

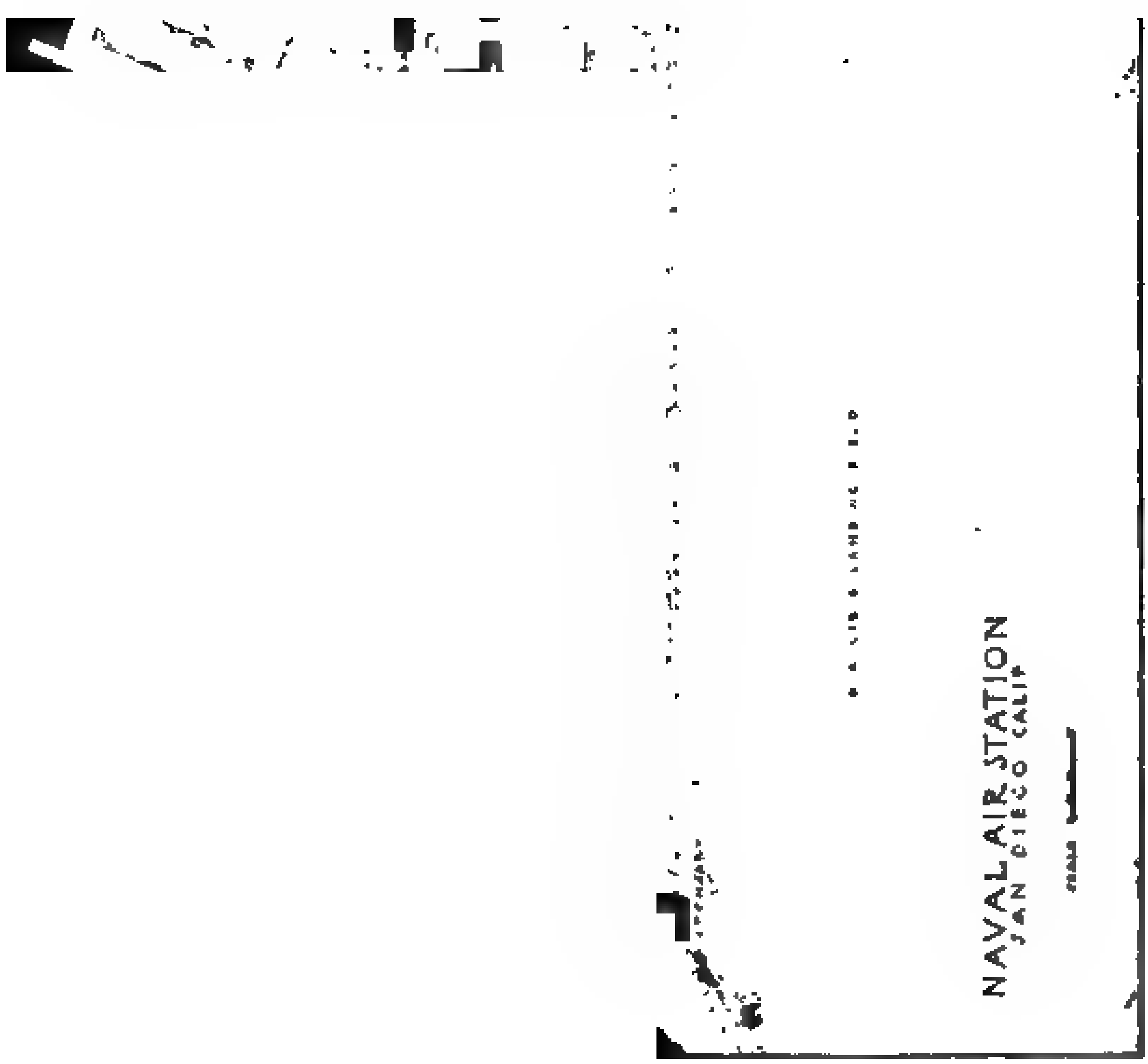
From the above description, which is typical of the whole station, it may be observed that the following principles of construction have governed: (1) Permanence, (2) fire-resistance, (3) utility, (4) architectural harmony, and (5) the greatest practicable measure of economy.

The station, whose general effect can be described as imposing, if not magnificent, has been attained at a total outlay, for both temporary and permanent construction, of approximately $2,500,000.

Naval aircraft factory, Philadelphia.—This brief résumé of naval aviation shore construction in the United States would be incomplete

Seaplane view of Naval Air Station, Pensacola, Fla.

Typical dirigible hangar, San Diego, Calif.

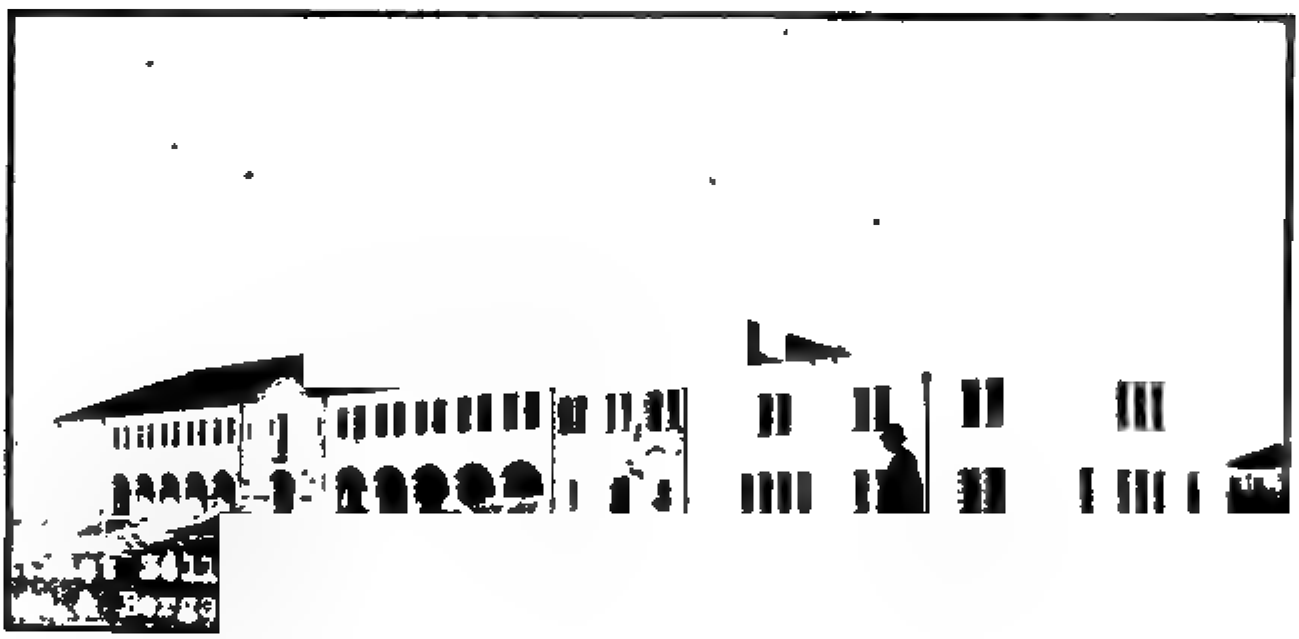


Plan of Naval Air Station, San Diego, Calif.

Administration building, Naval Air Station, San Diego, Calif.

Seaplane hangar, Naval Air Station, San Diego, Calif.

Commanding officer's quarters, Naval Air Station, San Diego, Calif.



Student officers' quarters, Naval Air Station, Dan Diego, Calif.

Barracks No. 2, Naval Air Station, San Diego, Calif.

without mention of the aircraft factory at the Philadelphia navy yard, constituting, in all its aspects, one of the most surprising performances of the war.

The general principles underlying naval experimentation and manufacturing governed in the installation of this plant, and its construction was pushed as an emergency undertaking of the war program. The original contract of $1,000,000 was let on August 4, 1917, and the whole structure—steel, glass, and maple floors—was completed on the 28th of November, 87 days later. Its immediately successful operation prompted a call for great extensions, and the final completion of the project, well ahead of the armistice, involved the expenditure of funds in the amount of nearly $4,000,000.

The buildings provided are of great size and excellent construction. The group includes the original factory proper, 400 feet square, an assembly building 1,080 feet long with an average width of 300 feet, a six-story reinforced-concrete storehouse, a large administration office building, an independent power plant, a dry kiln, heated lumber storage, an aircraft storehouse, and a garage. The plant is completely equipped with motors and handling apparatus, and a humidifying system permitting absolute control of temperature and humidity is installed. The floor space devoted to manufacturing during the war was 900,000 square feet, or more than 20 acres. The number of employees rose to a maximum of 4,000. On this basis the annual capacity of the factory is very large though impossible to state in terms of units produced—the question being analogous to that of the annual output of a navy yard along any other line. Repairs and overhaul constitute a large factor in the plant's activities at all times. It may be stated, however, that the aircraft factory was designed for a theoretical output of 1,000 F-boats per year, or a considerably larger number of a smaller type, which capacity would be quite practicable under the pressure of an emergency.

WAR CONSTRUCTION ABROAD.[1]

The first occasion for direct activities on the part of the Bureau of Yards and Docks in Europe during the World War was in connection with aviation. Protection of ships at the entrances to the harbors and near the shore in general was found to be of great importance, and it was decided to make full use of aircraft for that purpose.

Preliminary examinations were made and a number of stations were selected on the French and Irish coasts during the summer of

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[1] Contributed by Commander E. H. Brownell (C. E. C.), U. S. N.

1917. The Bureau of Yards and Docks began the providing of materials for building and for public-works construction at these stations, the most conspicuous items being in portable houses and other buildings and in the materials for hangars for aircraft. In November, 1917, the first public works officers went over, and from that time to the signing of the armistice the personnel expanded in numbers and construction proceeded rapidly.

The stations first handled and as listed up to March, 1918, consisted of the following:

List of United States naval air stations (foreign service).

Location.	Type.	Location.	Type.
Ireland:		France—Cont'd.	
Lough Foyle	Seaplane.	Brest	Kite-balloon.
Lough Swilly	Kite-balloon.	Guipavas	Dirigible.
Whiddy Island.	Seaplane.	Ile Tudy	Seaplane.
		La Trinite	Kite-balloon.
Berehaven	Kite-balloon.	Le Croisic	Seaplane.
Queenstown	Repair base and seaplane.	Paimboeuf	Dirigible.
Wexford	Seaplane.	Fromentine	Seaplane.
England:		La Pallice	Kite-balloon.
Killingholme	Do.	Rochefort	Dirigible.
France:		Saint Trojan	Seaplane.
Dunkerque	Do.	Pauillac	Repair base.
Treguier	Do.	Gujan	Dirigible.
L'Abervrach	Do.	Arcachon	Seaplane.
Brest	Do.	Moutchic	Seaplane school.

Later expansion included the following stations:

Location.	Type.	Location.	Type.
England:		France—Contd.	
Eastleigh	Assembly and repair base, northern bombing group.	Oye	Seaplane.
		St. Inglevert	Do.
France:		Italy:	
Autingues	General headquarters, northern bombing group.	Lake Bolsena	Do.
		Pescara	Do.
Campagne	Seaplane.	Porto Corsini	Do.
Day Wing	Headquarters.	Tunis:	
Le Frene	Seaplane.	Bizerta	Projected mine base.

Construction at each of the above stations included the necessary buildings for administration, officers' and enlisted men's barracks, storehouses, latrines, mess houses, repair shops, dispensaries, garages, and recreation rooms; excepting only where existing buildings were available for those purposes.

Reference is here made to the table inserted, giving particulars of all work performed abroad by officers of the Corps of Civil Engineers attached to the naval aviation forces. This table is extracted from the comprehensive statistical report of Lieut. Commander D. Graham Copeland (C. E. C.), U. S. N. (resigned.)

United States naval aviation shore construction abroad, 1917–1918.

RECAPITULATION.

Station.	Appraised value.	Area.	Seaplane hangars (wood and steel).	Dirigible hangars.	Bessanneau and Nestler hangars.	Kite-balloon hangars.	Slipways.	Aprons.	Barracks.	Storehouses.	Mess halls and galleys.	Hospitals.
		Acres.	*Square feet.*	*Cubic feet.*	*Square feet.*	*Square feet.*	*Square feet.*	*Square feet.*	*Square feet.*	*Cubic feet.*	*Square feet.*	*Square feet.*
England:												
Eastleigh	$1,317,363	165	204,000					13,475	64,120	1,626,640	19,520	10,255
Killingholme	1,562,060	138	286,540				44,400	250,500	81,084	60,900	21,377	700
Ireland:												
Aghada (Queenstown)	701,060	66	58,590				18,200	75,175	91,989	1,366,920	14,580	2,400
Berehaven	120,125	64				21,708			10,800	46,045	3,600	1,200
Lough Foyle	289,725	35	58,590				43,200	68,000	30,400	83,006	6,600	2,400
Wexford	322,800	41	39,060				12,250	44,000	38,418	248,588	4,800	2,400
Whiddy Island	331,475	60	39,060				6,300	47,000	33,920	90,400	8,400	4,850
Italy:												
Lake Bolsena	252,210	19			897,000		21,600		40,000	24,000	4,800	1,000
Pescara	286,300	14	71,840				18,600	52,500	91,250	32,912	6,400	10,375
Porto Corsini	350,200	26	60,675				12,000	48,000	43,950	40,000	10,000	117,200
France:												
Arcachon	249,175	15	39,000				5,600	127,500	30,180	69,900	4,140	2,420
Brest	335,250	29	58,590			12,000	10,400	65,120	109,190	113,596	9,640	1,440
Dunkerque	187,000	34	10,240		25,760				91,820	114,038	5,100	1,440
Fromentine	210,300	47	39,060				8,000	25,870	26,396	65,694	6,880	2,140
Guipavas	253,200	101		5,440,000					18,468	49,024	2,810	1,540
Gujan	224,390	133		5,420,000					12,200	45,350	3,140	2,140
Ile Tudy	178,865	15	19,530		24,180		46,000	44,840	22,340	33,273	7,500	2,140
L'Abervrach	162,148	32	29,295				13,000	36,000	25,105	50,320	5,436	2,140
La Pallice	182,055	10				16,000			6,420	28,034	2,340	1,440
La Trinité	94,360	9				16,000			11,640	23,600	2,588	
Le Croisic	165,020	7			30,250		7,500		14,366	53,856	18,093	3,122
Moutchic	260,830	168			36,300		8,400	87,190	40,414	50,308	9,482	1,716
Paimboeuf	708,595	64		10,885,000					26,291	34,157	7,409	3,063
Pauillac	1,485,695	166	84,620		6,500		7,350	52,500	572,430	1,330,813	36,862	40,480
St. Trojan	242,600	18	29,325				25,380	56,250	25,350	78,840	6,716	1,656
Treguier	111,300	5			24,200		3,000	8,725	18,508	32,314	3,391	2,140
Autingues (General Headquarters, northern bombing group)	77,160	18 134							12,120	115,760	6,280	1,200
Campagne	87,005	238			23,460				2,400		1,800	1,200
Day Wing (Headquarters)	24,719	24							3,180	11,000	2,340	1,200
Le Frene	83,353	201			42,660				6,120	50,000	4,200	1,200
Oye	145,335	208			88,160				13,400	24,000	7,480	
St. Inglevert	174,290	296			100,266				9,480	4,320	4,440	1,200
Tunis:												
Bizerta	40,800	20								271,480		
Total	11,216,758	2,620	1,127,925	21,745,000	1,298,766	65,708	311,180	1,102,595	1,325,699	6,270,800	252,004	232,716

United States naval aviation shore construction abroad, 1917–1918—Continued.

RECAPITULATION—Continued.

Station.	Garages.	Repair shops.	Recreation and Y. M. C. A.	Power houses.	Administration buildings.	Roads.	Water tanks.	Gasoline tanks.	Piers.	Telephone lines.	Water lines.	All buildings (cubical contents).
	Square feet.	*Square feet.*	*Square feet.*	*Square feet.*	*Square feet.*	*Sq. yards.*	*Gallons.*	*Gallons.*	*Square feet.*	*Miles.*	*Linear feet.*	*Cubic feet.*
England:												
Eastleigh	4,920	293,785	8,828	6,600	7,400	6,650				50	12,000	15,430,438
Killingholme	6,400	8,600	7,840	7,467	460	3,500				55	10,000	7,749,874
Ireland:												
Aghada (Queenstown)	4,393	44,261	5,155	2,512	8,600	25,350	7,000	20,000	7,440	20	10,590	5,304,305
Berehaven	1,200	640		4,065		4,600			5,250	2	16,000	1,374,960
Lough Foyle	5,040	6,140	3,160	640	2,880	10,380	360,000	10,000	6,720	12	4,405	3,285,717
Wexford	3,000	4,693	3,531	800	1,680	8,170	980,000	50,000	1,880	7	14,000	3,042,177
Whiddy Island	748	4,160	3,200	640	2,000	11,840	624,400	50,000	7,622	11	8,300	2,744,414
Italy:												
Lake Bolsena	1,000	5,000			1,000	19,500			1,400	10	4,500	1,643,370
Pescara	2,400		3,000		2,000	7,333			250	10	6,000	2,956,692
Porto Corsini	1,500	1,800		487	4,700		12,000		800	11	500	2,310,059
France:												
Arcachon	392	7,795	3,000	1,029	2,395	3,333	75,000	6,300	4,017	13	3,000	2,092,637
Brest	7,100	5,982	8,220	684	2,220	7,620	10,000	50,000		6	6,300	2,852,267
Dunkerque	980	1,850		280	4,500	4,000				15	5,000	1,298,841
Fromentine	642	2,440	3,870	574	3,382	1,800	10,000	18,000		12	2,230	1,715,164
Guipavas	600	5,708	3,980	140	1,540	3,800	12,500			9	4,720	5,901,880
Gujan	2,400	5,340	2,000	1,740	1,740	4,920				11	1,500	5,726,420
Ile Tudy	1,380	7,262	3,600	480	8,000	5,000	10,000	52,000		7	6,600	1,739,615
L'Abervrach	740	5,156	4,260	480	2,665	4,400	36,000	25,000		11	3,320	1,360,435
La Pallice	616	2,880	700		1,740	2,700	110,000			9	2,000	998,083
La Trinité		1,948		284	1,800	3,000	25,000			13	1,370	1,311,990
Le Croisic	1,511	4,222	240	220	4,152	2,000	41,080			13	1,000	1,165,388
Moutchic	1,400	10,346	6,504	1,430	2,206	6,830	20,000	13,000	4,220	12	3,350	1,407,446
Paimboeuf	3,221	5,891	9,503	639	1,652	8,500	16,390			12	3,400	11,801,161
Pauillac	8,400	182,530	33,965	6,231	53,080	8,000	210,000	50,000	3,800	60	12,000	15,190,759
St. Trojan	2,580	8,400		1,016	1,820	4,100	36,000		6,786	12	5,500	1,542,434
Treguier	1,250	3,248	3,265		1,599	2,650	7,320	3,900		6	5,000	862,233
Autingues (General Headquarters, northern bombing group)	6,625	2,300	900	120	4,920	4,827				75		654,187
Campagne	6,400		1,200	120	480	250				4		621,432
Day Wing (headquarters)					2,440	550				30		152,251
Le Frene	8,400	1,200	1,200			300				4		1,181,971
Oye	6,400		2,400							4		2,075,174
St. Inglevert	7,820	13,025	1,200	120	1,000	426				4		2,789,410
Tunis:												
Bizerta		2,280		288								350,103
Total	107,764	648,922	124,523	39,086	134,251	176,423	2,602,690	348,200	60,385	532	150,617	110,255,991

Location map, United States Naval Air Stations abroad.

The seaplane stations included also the necessary hangars for seaplanes and the necessary shore construction for the runways. Prior to the construction of the more permanent hangars, temporary canvas hangars were used to a considerable extent, the most common type being the "Bessoneau," which consisted of a canvas cover on a wooden framework. Those constructed by the United States forces were principally of wood, and were of sufficient width to take in the large bombing planes. The dimensions called for a clear opening of about 24 feet in height, 105 feet in width, and the depth was in general about 93 feet. The Bessoneau hangars were of a size to take only the smaller planes.

The dirigible stations were, in general, located 2 or 3 miles from the shore. They included hangars whose size was in general such as to afford a clear width of over 70 feet, a clear height of 80 feet, and a length of about 600 feet.

The kite-balloon stations were, as a rule, near the shore, and were for the accommodation of kite-balloons designed to be towed by destroyers. These balloons each required a clear space about 30 to 40 feet wide, about 30 to 40 feet high, and about 100 feet long. A fair-sized station would provide for three balloons inflated and three deflated.

The two repair bases were of great importance. The principal one of these was at Pauillac, on the Gironde River about halfway between Bordeaux and the ocean. This station included the principal repair shop, 250 feet by 600 feet, four hangars, 93 feet by 210 feet, and a great number of storehouses and other buildings. There were a considerable number of permanent buildings already on the site.

There were six stations in Ireland. That at Queenstown was expanded to a repair base. It was located at Aghada, "Aghada Villa" being used for officers' quarters. There was a camp there of the famous "Black Watch" Scotch regiment, the same that was in the Battle of Ticonderoga in the American wars of the eighteenth century. About half of the barracks buildings occupied by them were turned over to the Americans. Wexford was particularly interesting as being on what might be termed the southeastern corner of Ireland, where the channel narrows and where many ships were compelled to pass. Whiddy Island is at the head of Bantry Bay, on the southwestern corner of Ireland. Berehaven was also on Bantry Bay, but near its entrance. Lough Foyle and Lough Swilly are at the extreme northeast of Ireland, and protect shipping past that point. Besides the stations noted, a base for material was acquired in Dublin.

The station of Killingholme, England, was turned over completely to the Americans.

In the early summer of 1918 an officer of the Corps of Civil Engineers, Lieut. Commander F. N. Bolles, was transferred from St. Inglevert, near Dunkerque, to Eastleigh, England, to construct the assembly and repair base of the Northern Bombing Squadron. This was located near Southampton. It had originally been intended to locate this station in France, but the danger of a German drive down the channel coast of France had decided the authorities to choose a safer site in England. The function of the station was to assemble and repair planes for the bombing squadrons in France.

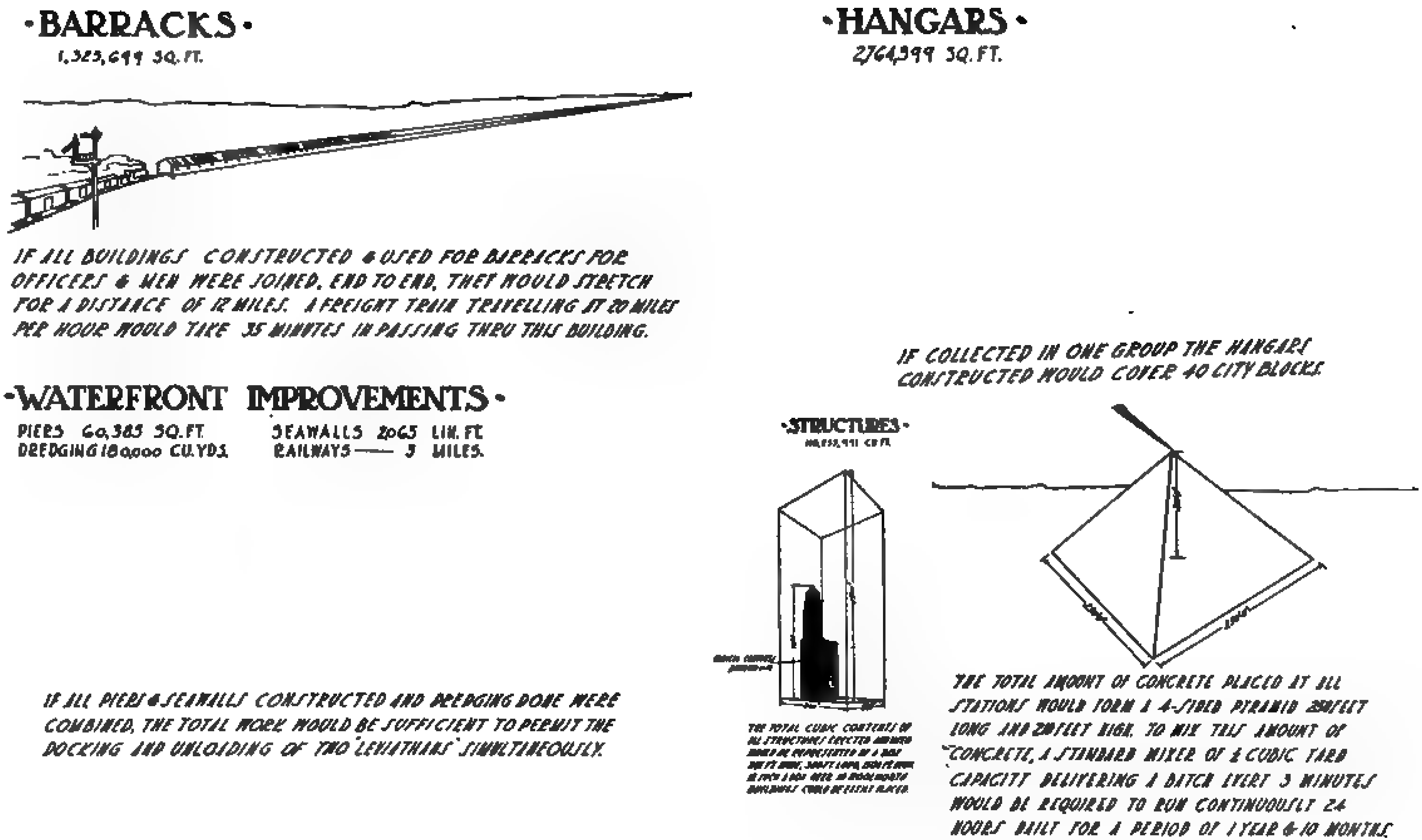
The station was originally designed by the British to serve as a reception park for aircraft. Parts and complete planes were to be received here direct from the factories and stored until needed. It was equipped with enormous storehouses and hangars, but there were accommodations for only 100, whereas the accommodations under American occupation had to be for 5,000 men. It was the civil engineer officer's function to provide barracks, mess halls, hospitals, lighting, sewage disposal, and recreation quarters for the 5,000. Additional facilities for the assembly and repair of planes had to be provided in the way of shops, a power plant, test stands, etc. The boilers for the power plant were shipped from the United States, but the ship which was carrying them was, unfortunately, torpedoed, and the officer in charge had to borrow boilers from the Portsmouth Navy Yard, where he was hospitably received by Rear Admiral Sir Stanley Colville, commandant of the yard. The officer was later obliged to go to Scotland to get some additional boilers.

The station was entirely completed and in full operation by the time of the armistice.

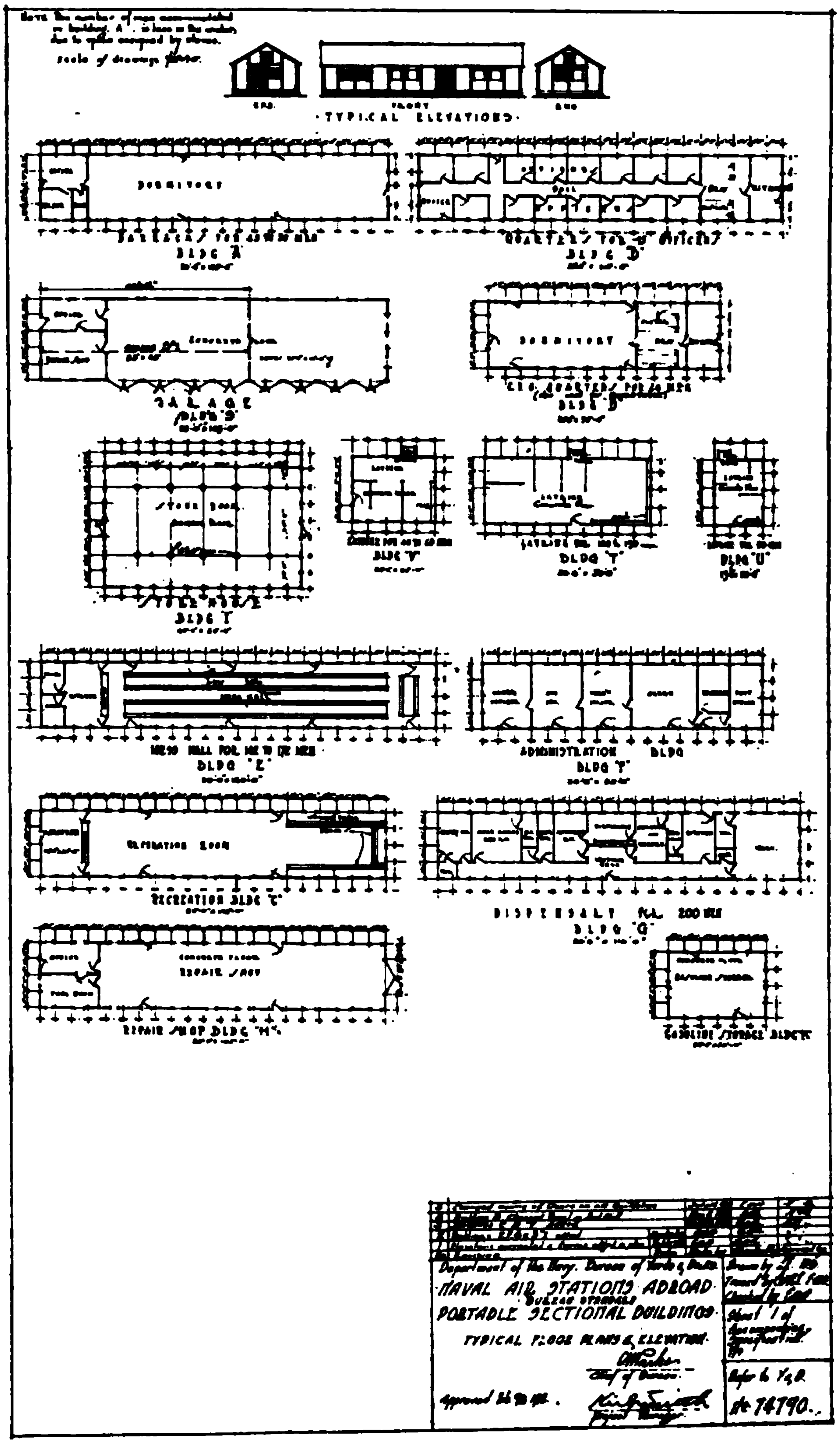
The Dunkerque aviation base was one of the most interesting in France. It was situated in the city, where it was subject to nightly bombing by the Germans, particularly when the moon shone. In this station, as in the great English aviation station at Felixstowe, it was necessary to construct bombproofs in which the men could take shelter.

The following incidents, related by Lieut. Commander F. N. Bolles, illustrate rather vividly conditions existing in the Dunkerque salient:

From Paris I was sent to St. Inglevert, near Dunkerque, to construct a small squadron base. The life at St. Inglevert was very interesting and at times exciting, for the fighting lines were not far distant at that time (June, 1918). The near-by British and French squadrons were going over the lines at night, whenever the weather permitted, on bombing expeditions, and the old French chateau in which we American officers lived was the rendezvous for Belgian, French, British, and Portuguese officers from miles around. Upon one of my trips to Dunkerque, a German long-range shell wrecked our seaplane hangar, spraying shell fragments about promiscuously. None of us was injured, though morale for a few moments was at a low ebb. On another occasion, a launch which had been sent out to pick up a disabled American seaplane was captured by the Germans. The station doctor was among those taken prisoner.



Graphical representation of certain classes of construction projects at United States Naval Air Stations abroad.



Types of standard portable buildings for United States Naval Air Stations abroad.

All of the other French stations were located on the coast extending from the Brittany peninsula to the latitude of Bordeaux. The Brest station was contiguous with the French navy yard. Treguier, L'Abervrach, Ile Tudy, La Trinité, and Le Croisic are on the Brittany coast, Guipavas is 2 or 3 miles inland from Brest. Moutchic was located on a lake and was used exclusively as a school.

A great deal of work was done by the station forces, using principally materials sent from the United States. Considerable work, however, was done by local contractors. This was particularly the case in the Irish stations and at the French stations of Brest, Arcachon, and Moutchic. Both French and English construction showed a tendency to more permanent work than American engineers would undertake for war emergencies, both in the buildings and in the ground layout, including shore protection, runways, etc. This was partly accounted for by the great dearth of lumber. It seemed best in most cases to let these contractors follow their own methods, so long as results were accomplished.

Considerable construction already in place was turned over to our forces. Treguier station was in active operation before we took it over, as was the dirigible station Paimboeuf. At L'Abervrach, La Trinité, Fromentine, and Arcachon we made a fresh start. Other stations were intermediate in condition between these extremes. In both France and England, naval public works are administered by civilians detailed from another department of the Government instead of by a special corps of civil engineers as in the United States Navy. This occasioned some uncertainty and delay. Strictly speaking, a request from a United States officer had to pass through a French or English officer to a civilian official, each of these being either a district representative, or possibly at headquarters in Paris or London, and thence to the local official of public works, and so to the contractor. Of course, we cut across this circuit to a great extent, and took matters up directly with the parties who were to execute them.

There were some peculiar classes of workmen on the grounds; there may be noted particularly enlisted Kabyles, of the French Army, from Northern Africa, German prisoners, and at one of the fuel-oil stations a gang of Bulgarian deserters. The Kabyles at an airplane station at one time refused work. Their commanding officer settled this; to use his own words, "I did not give them anything to eat"; they returned to work. On another occasion the same outfit struck or mutinied. It was reported that their officer drove the ringleaders into a building with a shotgun, and so ended that difficulty.

The liaison features at headquarters were interesting, being located in London in the old buildings of the Admiralty, and in Paris in the building which duplicates the Hotel Crillon, and with

it looks out on the Place de la Concorde, exactly as it did on the day of the execution of Louis XVI. There interviews were had with le Capitaine de Fregate Gerspach and the two Lieutenants de Vaisseau L'Escaille and Thierry. M. Minard, with the title of Ingenieur en Chef des Ponts et Chaussees, but "serviçant aux travaux hydrauliques," was in a building close to the Eiffel Tower. His colleague, M. Mallat, with the same title, was in charge of public works at Brest, his office being in an ancient building of the navy yard. All this, along with the solid construction usually employed, gave an impression of Old World conservatism, but in so far as could be judged, results were promptly accomplished and usually in the best way practicable under the difficult circumstances of the war. For one item, the variety of designs for dirigible hangars adopted and actually used by M. Minard was particularly impressive; they embodied every means available.

The most active coadjutor for the Irish station (Aghada) was Lieut. Mulville, who in private life was a civilian engineer of South American and other experience. At London headquarters also some of the officers concerned in public-works construction were reserve officers who in civil life were civil engineers.

[Certain facts abstracted at this point from the report of Lieut. Commander Copeland present phases of the activities of the aviation construction forces abroad in a graphic manner.]

The task set the Corps of Civil Engineers abroad in providing for naval aviation was, roundly, that of establishing all proper quarters and facilities for the operations of 20,962 officers and men in the Navy's flying forces, foreign service. This force was almost half as great as the Navy's total prewar strength and almost double the prewar strength of the Marine Corps.

Barracks aggregated 1,325,699 square feet; if joined end to end, they would extend a distance of 12 miles.

If all piers and sea walls constructed and dredging done were combined, the total project would permit the docking and unloading of two ships of the magnitude of the *Leviathan* simultaneously.

The total volume of concrete placed at all stations would form a bulk approximately equivalent to one of the pyramids of Egypt, that of Menkaura at Gizeh.

Twenty-nine telephone exchanges were installed, and 1,323 miles of telephone line constructed.

Twenty-eight power houses were built, admitting of an output of energy equivalent to the demands of an average American city of 40,000 inhabitants.

The total cubic contents of all structures erected and used would be represented by a box sufficient to contain the Woolworth Building ten times over.

Frame dirigible hangar, United States Naval Air Station, Paimboeuf, France; early construction view.

Frame dirigible hangar, United States Naval Air Station, Paimboeuf, France; late construction view.

Canvas dirigible hangar, United States Naval Air Station, Paimboeuf, France.

Seaplane view of United States Naval Air Station, Arcachon, France.

Hospital facilities were provided for 3,000 patients.

Water supplies with an aggregate yield of 153,000,000 gallons per year were developed. A steel tank of the total capacity of all tanks erected would encircle the Washington Monument. Such a tank set on a composite of all the steel towers built for water-supply purposes would form a structure twice as high as the Eiffel Tower.

Covered storehouses were provided having an aggregate area exceeding the prewar storage at the navy yards at New York, Philadelphia, Charleston, and Puget Sound combined.

If collected in one group, the hangars constructed would cover 40 city blocks.

Aeroplane slipways constructed, if laid to a uniform width of 20 feet, would extend nearly 3 miles in length. On such a slipway 65 per cent of the German aeroplanes surrendered to the Allies could be easily drawn up for inspection.

Tonnage transported by trucks on these construction projects abroad amounted to 162,000 ton-miles.

Lumber used aggregated 21,834,000 board feet—equivalent to 4,127 miles of planking 1 foot wide.

Stations in Brest and vicinity.—Having briefly surveyed the field of aviation construction abroad, the bureau is fortunate in being able next to present some first-hand details of construction as executed at Brest, Ile Tudy, L'Abervrach, Guipavas, and Treguier (see map), from the account of the civil engineer in direct charge of these operations, Lieut. C. P. Conrad. These aviation stations were constructed in the vicinity of Brest as part of the French and American naval air program of defense of the coast of France. The sites of the stations were chosen by a joint commission in the late summer of 1917, with the idea of dividing the territory about evenly between the two services.

BREST.

Brest was to be a combined H-16 seaplane and kite-balloon station, with a complement of 600 men. The ground chosen was a strip of made land 3,000 feet long, 250 to 300 feet wide, fronting on the inner harbor of Brest.

When our first construction forces arrived in France in November, 1917, work was already under way at the Brest station under the supervision of the French civil engineers of the department of Travaux Hydrauliques. They had prepared complete plans and had let contracts to French contractors for the construction of barracks, launching slips, and a wooden hangar. A force of 50 German prisoners and 100 Moroccan laborers were doing force-account work on roads and foundations at the time of our first inspection.

All expenses incurred were charged to our account and were billed to us quarterly. The French Government charged us 20 per cent on all these accounts to cover their engineering and overhead expenses.

Early construction work by our own forces was carried on in close cooperation with the French, and with the idea of completing the station as they had planned it, adding from our own material barracks and hangars to bring its

capacity up to our requirements. The United States naval forces had use for all their own material elsewhere on new projects, and we were glad to count on all the buildings that the French could promise us at Brest.

Our construction up until the receipt of materials from the United States in April, 1918, consisted of erecting temporary portable barracks and tents borrowed from all sources to house our rapidly growing complement, and of preparing foundations and floors for our seaplane hangars. Construction materials and tools were almost unobtainable in the French market. Cement was imported from England. The sailors broke by hand all the rock for the first hangar foundations and floor. Our concrete mixer obtained for the second hangar was an old continuous type that had been used in the construction of fortifications on the opposite side of the bay. A working party on a six-ton truck started after this mixer at 4 a. m. one Sunday, made the 150-mile round trip, and returned with it at 2 a. m. Monday morning. We bought the hand tools essential to our preliminary work from French hardware stores, but the stocks were depleted from three and a half years of war and the models were crude. Carpenters' hammers were rectangular blocks of steel. A request for claw hammers was met by the indignant protest of the merchant that good carpenters used pincers to pull nails.

The sailors, most of whom had enlisted for aviation and were without construction experience, worked wonderfully well with their crude equipment. Barracks and tents for 300 men and complete foundations and floor for two bays of a seaplane hangar were finished when the first shipload of hangar lumber, tools, and portable barracks arrived from Pauillac in the latter part of April, 1918.

The erecting of the hangar started at once with two 8-hour shifts, because there were tools enough for only 75 men. In 15 days after the last load of lumber left the ship, the hangar, 93 by 214 feet, was completed.

Meantime the work started by the French had made slow progress for lack of lumber. None of the barracks were completed, though half a dozen were started. The distribution of lumber had been placed under the war ministry, and the contractor could not get deliveries. No work had been done on the seaplane hangar, which was to have been completed February 1, 1918. Finally we gave up hope of seeing this work go forward and had all French contracts canceled on August 23, 1918. Three barracks had been completed, and we finished others with our own material. The hangar was not sufficiently advanced to be of any use to us, and we substituted for it an additional hangar of the American design.

After midsummer, 1918, tools and construction materials came in rapidly from the United States. It became necessary to assemble planes at Brest because they were received as deck loads on the troop transports and were too bulky to transfer by rail to Pauillac for assembly. This greatly increased the size of the station, the complement being raised from 600 to 800 men, and machine-shop and hangar space was provided for assembling work. The machine shop, 100 by 30 feet with an L 30 by 30 feet, was constructed entirely of seaplane crates. The panels were used whole for the sides and roof. The posts, plates, and rafters were made of the frames of the crates. The walls were made two panels thick to satisfy the requirements of Assembly and Repair, who were very skeptical regarding this type of construction. It proved entirely satisfactory. This unexpected source of lumber proved a great boon and all small structures not the size of standard portable sections were thereafter built of seaplane crates.

At the time of the armistice, Brest station had barracks space for 1,000 men, quarters for 50 officers and 75 chief petty officers, 3 wooden seaplane hangars

Seaplane view of United States Naval Air Station, Guipavas, France.

Dirigible hangar, United States Naval Air Station, Guipavas, France.

(93 by 214 feet each), a steel kite-balloon hangar (100 by 120 feet), and auxiliary buildings such as galley, mess halls, storehouses, machine shops, garages, and offices to meet the needs of a station of this size.

Construction stopped with the armistice and demobilization began.

The Brest station was the only one of naval aviation's establishments taken over by the French Navy, although we had understood up to the armistice that several others were also wanted. Only the equipment was moved from the station, and the French were given formal possession on February 22, 1919. But it was September, 1919, before the minister of the navy approved this transfer and agreed on the financial terms, and it was December before the transfer received the approval of the naval appropriations committee of the Chamber of Deputies, an act necessary to make it legal.

ILE TUDY.

The construction of the seaplane station at Ile Tudy was also in the hands of the French at the time of our arrival. This station had been laid out on a much smaller scale than that at Brest. Quarters for 200 men were fitted out in the loft of a large stone building that had served as a sardine cannery. Two canvas hangars housed the French-built planes, and a track laid directly on the mud flat served for launching them. Substantial wooden buildings had been built for carpenter shop, machine shop, and aviation stores, and stone buildings for garages and oil storehouse.

Fresh water was obtained from the village supply, which was brought through 13,000 feet of 3-inch clay pipe from a small spring 14 feet above the station. It provided only a trickle at each end of the village, where the women stood in lines for hours to fill their pitchers. Our consumption was far beyond French standards, and increasing the water supply was the first work we undertook here. All the ground water of the sandy spit on which the station was built is brackish, a condition which necessitated our going 2 miles inland to dig a well. Water was hauled by truck from here and from a stream about 4 miles away.

The village pipe line received only one-third of the flow of the spring, while a community laundry basin used by half a dozen families received two-thirds. The division was made in a locked stone weir chamber on a marquis's estate and the game warden could not be persuaded that military necessity was any cause for changing this century-old partition. Fortunately for us, the marquise came to her country estate earlier than usual that year to escape air raids in Paris, and granted the American Navy complete control of the spring, a concession that through official channels could not have been obtained in less than three months. The increased spring flow and the water hauled in proved sufficient for what the French officers regarded as our extravagant use.

Ile Tudy operated brilliantly with only French equipment, but gradually, as portable buildings and lumber were received from the United States under Yards and Docks orders, barracks, recreation hall, and dispensary were provided for the men in place of the lofts in which they had slept with the carrier pigeons. One of our wooden seaplane hangars, 214 by 93 feet, supplemented the French canvas ones, which were raised on 4-foot piers to accommodate HS-1 seaplanes. Concrete aprons and a concrete launching ways replaced the French track when the station began to operate with the heavier American seaplanes in September, 1918.

At Ile Tudy the French completed the station as they planned it, providing hangars, shop equipment, and quarters sufficient for the bare necessities of op-

eration. We enlarged the establishment to permit more efficient operation with heavier machines, and to provide a reasonable degree of comfort for the men.

After the armistice, the French Navy having indicated that it had no use for this station, the portable buildings were knocked down and turned over to the United States Army, who had great need for them in building up the embarkation camp near Brest. The wooden hangar was razed and transferred to the Army as salvage lumber for tent floors, etc. The sardine cannery and the land were returned to their owners, who exacted no damages for our occupation.

L'ABERVRACH.

The seaplane station l'Abervrach, about 20 miles north of Brest at the entrance to the English Channel, was located on a rocky island of 16 acres' area, three-quarters of a mile across the inlet from the village of that name. The island at low water was connected with the mainland on the opposite side of the inlet.

No work was done on this station by the French, but they secured the site for us by condemnation and assisted with the preliminary surveys. Our first detachment of 40 men arrived on January 26, 1918. They were quartered in the village, as there was no shelter on the island, and went to and from work in fishing boats. A pier was constructed of loose stones, there being no means of access to the island. The stones were collected in carts that we hired locally through proclamation of our needs by the town crier. The carts were boxes set on two wheels. To dump them the horse was unhitched, allowing the shafts to fly up in the air. The drivers were women and children, there being some little fellows who did not look over 6 years old. These people spoke only Breton, a language entirely different from French, which made it impossible to arrange a schedule of work with them. They came and went without a word, receiving their pay from us through the mayor of their commune.

Pier construction, road work, and grading for the hangars were carried on by working parties living in the village until March. The inlet was so rough on some days that boats could not reach the island. Tents were borrowed from the United States Army, and the detachment moved over to the island about the middle of March. Three French portable barracks were received and erected in April.

Hangar lumber and American portable buildings were received from Pauillac in May. All this material was unloaded from the ship in Brest, hauled by truck a mile to the narrow-gauge station, there loaded at the rate of eight 10-ton cars a day, and hauled to l'Abervrach, four cars per train, in two trains per day, as this was the maximum capacity of the railroad. At l'Abervrach the material was unloaded from the cars and taken three-quarters of a mile across the inlet in 40 and 50 foot motor sailers, fishing boats, rafts, and on the one 10-ton flat lighter in the harbor. The harbor was too small to receive any supply boats direct from Pauillac.

Water could not be obtained on the island, and at first was carried from the village in gasoline drums. Four wells were dug on the mainland with which the island connected before sweet water was found. This supply was then piped 2,000 feet to the station across the tide flat.

In August, 1918, the station was ready to operate, with one hangar 214 by 93 feet, concrete apron, launching ways down to mean tide, machine shop, office, barracks and mess for 300 men, quarters for 30 officers, and a usable pier. Construction continued until the armistice. The ways and the pier were lengthened, and grading for an additional hangar proceeded.

After the armistice, as the French did not want the station, it was torn down, and all the salvaged building material was turned over to the United States Army for their camp construction near Brest. Within 24 hours after our men left the island the peasants from the surrounding country had carried off every splinter of wood and had completely torn down the out-door oven to get the fire-brick.

The island was returned to its owners bare as before, but a valuation commission allowed them 26,000 francs damages. This sum was over three times the value of the land, but we found that 25,000 francs of it was for destruction of the fences. The 16 acres had been divided into 108 distinct parcels, each fenced witih a boundary work varying from a single line of stones to a turf wall four feet high. These had been valued at the price of such fences on the mainland, where turf walls six feet high are used. The damages were reduced to 5,000 francs.

GUIPAVAS.

The most interesting station of this group from a construction standpoint was the dirigible station at Guipavas. Erecting barracks and seaplane hangars was comparatively simple even with inexperienced sailors, and most of our difficulties at the seaplane stations lay in getting materials; but erecting the timber dirigible hangar with inexperienced men and the equipment available was an interesting task.

The camp at Guipavas was started about the middle of March, 1918, as the French did not allow us to occupy the land until then. Working parties from the Brest air station erected a borrowed hospital barracks as galley and mess hall and 10 British "10-men" tents that were really crowded for four men. The first detachment of 50 men arrived at 8 o'clock at night, separated from their hammocks and bedding.

Four hundred yards of road was hastily built in to the hangar site just in time to receive the first shipload of lumber, April 3, on the U. S. S. *Bella* from Pauillac. The lumber was hauled by truck 7 miles from Brest to where the *Bella* docked.

The only erecting equipment received with the lumber was two 60-foot gin poles; so while the hangar site was being graded and the first foundations put in, we collected equipment. The French, on a similar hangar, assembled the trusses complete on the ground and erected them with a traveler that picked them up at five points. Even with this traveler they dropped four trusses and killed two men; so it was evident that because of the limberness of the trusses we could not pick them up with two gin poles. The French contractor offered to rent us his equipment, but demanded a fabulous price and would not promise immediate delivery.

Wire rope was obtained from the French navy yard and manila rope from the American naval base. Two steam winches for the gin-pole lines, together with the large blocks, were rented from a French machine shop, and an overhauled tug boiler was bought from a French shipyard. The hand winch on the tower was borrowed from the French balloon station. This miscellaneous equipment operated satisfactorily all through the job.

The assembled truss was laid on the ground with the hips opposite the foundation piers on which it was to be erected. Wire ropes passing over the top of each gin pole were fastened to the truss at these points, and a wire rope passing over the top of the tower was fastened to a stiffening stick lashed to the truss about 8 feet below the peak.

In raising the truss, the entire load was carried on the two gin poles, and the line from the tower was used only to keep the truss from bending unduly. While it was being raised, the foot of the truss was shoved forward on skids toward the pier. The first three trusses were held in position by guy lines until the tower bracing was placed. The trusses were assembled and raised at the rate of one a day. No faster method was sought, as the erecting went faster than we received material.

The hardest part of the work was placing the purlins to connect the first trusses, as only half a dozen of the men had ever done any "high" work, and it took time to train others to work aloft.

At the time of the armistice this hangar was practically complete. Corrugated metal from the States was placed on the roof and a third of the way down the sides. Below that point the sides were covered with French asbestos shingles 2 feet square, a very light and easily placed covering. Rolling doors were provided at each end, though only the east one, giving access to the French landing field, was to be used at first. The wind-break around this door was practically complete. The successful prosecution of this work was due in large measure to the energy and resourcefulness of Carpenter Stuart B. Scruggs, who was in direct charge of the construction work at the station from the beginning until October, 1918.

The French navy informed us after the armistice that they would like to retain only the hangar as part of their station. The camp buildings and all surplus lumber were sent to the United States Army at Brest.

TREGUIER.

Little construction work was done by our forces at the seaplane station, Treguier, as this station had been operated by the French since 1917, and was turned over to us complete in August, 1918. Additional barrack and mess accommodations and officers' quarters were constructed. A fresh water supply was piped in from a spring 3,000 feet away. The canvas hangars were modified to give the necessary headroom for our HS-1 planes, but no other changes of importance were made.

After the armistice this station reverted to the French except for the barracks we had erected, which were transferred to the United States Army at Brest.

CHAPTER XIX.

UNITED STATES HELIUM-PRODUCTION PLANT, FORT WORTH, TEX.

There was first observed in the spectrum of the sun's rays, in 1868, a line indicative of a previously unknown element, and thereupon attributed to a hypothetical element, which was called "helium." Helium was first identified as an actuality in 1895 by Lord Rayleigh and Sir William Ramsay, and was subsequently found to occur in the earth's atmosphere to the extent of 4 parts in 1,000,000, and in certain pools of natural gas in appreciable quantities.

The use of helium as a buoyant agent in lighter-than-air craft was conceived by British scientists in the early stages of the war. Helium is adapted to such use by its chemically inert nature and its specific gravity, being lighter than any known substance except hydrogen. Because of the inflammability of hydrogen the advantage was obvious of substituting for hydrogen as the buoyant agent in balloons and airships a gas which is noninflammable and at the same time has a high lifting power. Helium has about 92 per cent of the lifting power of hydrogen, and will retain balloon buoyancy longer than hydrogen because of its slower rate of diffusion with the elements of the atmosphere through the balloon fabric.

The British, being unable to ascertain a feasible source of supply, soon after the United States entered the war requested American authorities to institute investigations along this line to determine the feasibility of obtaining helium from natural gas. The aircraft board on August 4, 1917, allotted to the Bureau of Mines $100,000, half each from the War and Navy Departments, for exploration and experimentation. As a result of a survey of gas fields by the Bureau of Mines, it was determined to exploit the Petrolia (Tex.) field, leased by the Lone Star Gas Co., for the extraction of helium from natural gas.

Funds were allotted for experimental purposes, and three experimental plants were constructed and operated, at Fort Worth and Petrolia, Tex., based upon three different processes for the separation of helium from natural gas. As a result of these experiments it was decided by the aircraft board to construct a helium-production plant utilizing the process developed by the Linde Air Products Co., and funds were allotted equally by the War and Navy Departments for this purpose. It was mutually agreed between the

two departments that the Navy should construct the plant and have cognizance of its operation.

The plant was designed by the Bureau of Engineering, the Bureau of Yards and Docks, and the Linde Air Products Co., in consultation. The Bureau of Engineering contracted with the Linde Co. for the design, manufacture, and installation of the special separation apparatus. The Bureau of Yards and Docks constructed the plant and facilities accessory to the project, purchased certain apparatus, and installed all of the equipment except the separation apparatus. The plant is being operated under the cognizance of the Bureau of Engineering.

The helium-production plant was located at North Fort Worth rather than adjacent to the wells at Petrolia, for economic reasons. If the plant were located at Petrolia it would be necessary to construct a power plant or to transmit power about 90 miles. Surface water in adequate quantities is not available at Petrolia, and the artesian conditions in that vicinity are poor, due to the underlying pools of gas and oil. Furthermore, the labor, railroad, and highway facilities at Petrolia are very poor. At North Fort Worth a reliable supply of power is available, the railroad and highway facilities are excellent, and an adequate water supply may be obtained by driving wells to a reasonable depth.

A contract was entered into with the Lone Star Co., whereby Petrolia gas is to be furnished by that company, processed, and the discarded gas from the production plant is to be returned to the Lone Star mains. The gas extracted, absorbed, or dissipated in the production of helium is to be paid for at prevailing commercial rates. The Lone Star Co. further agrees, for certain consideration, to draw not more than 10,000,000 cubic feet of gas per day from the Petrolia field, as long as the open flow from the field does not exceed 75,000,000 cubic feet per day. The consideration to the Lone Star Co. for this conservation is assumed to represent the cost to that company of the construction and operation of pipe lines to draw on other fields to supplement the maximum allowed draft from the Petrolia field.

NATURAL-GAS PIPE LINE.

The location of the United States helium-production plant at North Fort Worth entailed the procurement of a pipe line to convey the natural gas from the wells to the plant. The existing line was the 16-inch pipe line of the Lone Star Gas Co. The Lone Star Co. piped to Petrolia certain nonhelium-bearing gas from Oklahoma, which was mixed at that point with Petrolia gas. To process this mixed gas for helium would have necessitated the handling of a larger quantity of gas to produce a given quantity of helium. There-

Bird's-eye view of United States Helium-Production Plant, Fort Worth, Texas.

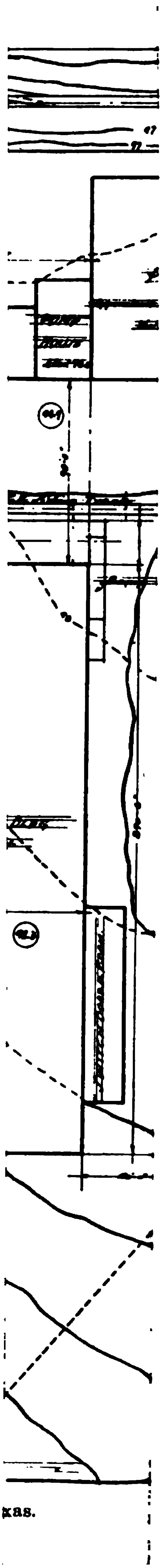
fore it was agreed that the Government should build a parallel pipe line of 10 inches inside diameter to convey Petrolia gas only. The length of this line is approximately 96 miles to map scale, although the actual length is over 100 miles, because of the rolling terrain over a large portion of the length. This is the longest gas pipe line in the United States without an intermediate compressor station.

Right of way.—The Lone Star Gas Co. in 1909 laid a 16-inch gas line from Petrolia to their measuring station adjacent to the site of the helium-production plant at North Fort Worth. At that time the Lone Star Co. purchased easements for the laying of two parallel pipe lines between these two points, at a cost of $32,784.40. In order to expedite the laying of the Government pipe line, the Lone Star Co. consented to sell their available easements to the department. It was found that the diversion of the route from that of the Lone Star Co. for a distance of about 9 miles between Newark and North Fort Worth would shorten the line about 3,200 feet and avoid several stream crossings, so easements were purchased by the department to effect this diversion.

Pressure.—When gas wells were first drilled in the Petrolia field they showed closed pressures greater than 700 pounds per square inch. The pressures have decreased greatly, however, owing to the diminution of the supply, so that the present pressures are less than 150 pounds per square inch. In order to convey a sufficient supply for the use of Fort Worth and Dallas, the Lone Star Co. built a compressor station at Petrolia intended to furnish a pressure of about 300 pounds per square inch. The compressor station will be used also to furnish the pressure for the Government line. The present operating pressure varies between 200 and 300 pounds.

Capacity.—The derivation of a universal formula for the discharge or capacity of a pipe line is impossible, since many indeterminate factors are present. Formulæ have been deduced, however, which are an approximate indication of the capacity. According to the formula by F. H. Oliphant, of the United States Geological Survey, the 10-inch pipe line from Petrolia to North Fort Worth, 104 miles in length, will discharge the following quantities of gas:

Intake pressure per square inch.	Discharge pressure per square inch.	Capacity per 24 hours.
Pounds.	*Pounds.*	*Cubic feet.*
300	150	9,300,000
300	200	8,000,000
300	250	5,900,000
250	150	7,200,000
250	200	5,300,000
200	125	5,650,000
200	150	4,750,000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SEPARATION OF HELIUM FROM NATURAL GAS.

Analysis of Petrolia gas.—The analysis of the effluent from the wells at Petrolia varies slightly in the per cent content of each component. The properties of each component gas, with the average content, are tabulated as follows:

Name.	Formula.	Content, per cent by volume.	Observed specific gravity (hydrogen=1).	Critical temperature, °C.	Critical pressure in atmospheres.
Methane	CH_4	55.34	7.98	−95.5	50.0
Ethane	C_2H_6	11.66	15.61	34.0	50.2
Carbon dioxide	CO_2	.34	22.00	30.9	73.0
Oxygen	O_2	Trace.	15.90	−118.0	50.0
Nitrogen	N_2	31.72	14.20	−146.0	33.0
Helium	He	.94	1.97	−268.0	2.3

The first two items above include slight proportions of other hydrocarbons. It will be noted that this gas contains no carbon monoxide, free hydrogen, sulphur gases, or unsaturated hydrocarbons, the presence of any of which would have introduced other difficulties in the separation. While the gas is at atmospheric pressure during one stage of the process, oxygen will probably be absorbed from the atmosphere, so that a larger content of oxygen will have to be separated.

The calorific value of the Petrolia gas is somewhat less than 800 B. t. u. per cubic foot, this relatively low heating value being due to the relatively large nitrogen content.

Nature of process.—Helium is extracted from the natural gas by effecting the liquefaction of each of the other gases, except carbon dioxide, contained with helium in the natural gas. This liquefaction is effected by the utilization of the process developed by the Linde Air Products Co. in their experimentation at the helium experimental plant No. 1 at North Fort Worth. This process consists essentially of the compression of the incoming gas to a high pressure, the removal of the heat of compression by a circulation of cold water, the progressive cooling resulting from the expansion of the highly compressed gas through an expansion valve to a low pressure, and the application of the cold waste gases and closed external refrigerating cycles of nitrogen and carbon dioxide as refrigerating media. The hydrocarbons, oxygen, and nitrogen condense in the order named. The carbon dioxide content is removed from the incoming gas by chemical precipitation effected by contact with limewater, which is sprayed into the incoming gas. The helium, which withstands the cold and pressure necessary to liquefy the remaining components, is finally recovered and stored in high-pressure cylinders for the requirements of the service.

SITE.

The helium production plant is located at North Fort Worth, in Tarrant County, Tex., about 1 mile north of the city limits of Fort Worth and about 3 miles north of the Tarrant County courthouse in Fort Worth. The site comprises 19.4 acres of fairly level land and is entirely cleared. The purchase price of the land was $409 per acre. A draw, draining about 270 acres, crosses the western portion of the site in a south by southeasterly direction. The various buildings comprising the plant were located on the higher ground toward the east side of the site to avoid this draw. The site consisted of grazing land entirely turfed. The top soil is a loam to a depth of 1 to 6 feet, underlain by a bedrock of hard and unfaulted limestone.

BUILDINGS.

The locations of the buildings with reference to each other were governed by the cycles of gases through the process, so as to require minimum lengths of piping, especially high-pressure piping, between buildings. Inasmuch as the War Industries Board requested that all buildings be constructed of materials other than structural steel, the principal buildings were designed of a light concrete construction. A large sash area was required for lighting the large buildings and allowing the escape of leakage gases, and this type of construction was very well adapted to such features. Several buildings were advantageously designed of frame and stucco. The only structural steel included in the design of the plant was for transformer towers and small miscellaneous items.

Compression building.—All of the compressors and carbon dioxide refrigerating units are installed in the compression building. This is a one-story building 97 feet wide, 290 feet long, and 32 feet high. A door is provided in each of the longitudinal bays in each side of the building to facilitate egress in case of combustion of escaping gases. A 20-foot concrete platform is provided at the end of the building adjacent to the railroad siding for the handling of cylinders and equipment. The building is provided with a concrete floor throughout, except in several panels adjacent to the loading platform, which are laid with wood block, so as to be nonsparking under trucking of cylinders.

Separation building.—The Linde separation apparatus is installed in the separation building, which is one story in height with a clearstory central portion to admit the high three-stage stills. This building is 68 feet wide and 199 feet long, with a height from grade to the top of the parapet walls of 42 feet and 27 feet, respectively, for the central and outer portions.

Boiler and pump house.—The boiler and pump house, adjacent to the cooling pond, is one story in height, 49 feet long, 45 feet wide,

Interior view, separation building, United States Helium-Production Plant, Fort Worth, Texas.

Interior view, compressor building, United States Helium-Production Plant, Fort Worth, Texas.

and 18 feet and 15 feet high, respectively, from grade to the tops of the parapets of the pump house and boiler room, with concrete walls, floor, and roof, steel sash, and metal bifolding and hinged doors.

Pressure-reducer house.—The pressure-reducing valves are installed in a concrete building with steel sash, 17 feet wide, 27 feet long, and 14 feet 6 inches high to top of parapet wall.

Nitrogen cylinder house.—The nitrogen cylinders to provide an equalizing supply to the nitrogen compressors are housed in a one-story concrete building 14 feet by 11 feet 6 inches by 18 feet high.

Office and laboratory building.—The office and laboratory building is occupied jointly by the Government and Linde personnel. The building is a two-story frame stucco building with concrete foundations and steps, 40 feet wide, 62 feet long, and 26 feet high from grade to the second-story ceiling. This building provides two office rooms, one toilet, and a laboratory on the first floor, and eight office rooms and one toilet on the second floor.

Building for carbon dioxide removal system.—A frame building provides for the housing of pumps, motors, and limewater storage and filter tanks between the scrubbing tanks of the CO_2 removal system.

Lime mixing shed.—The lime mixing vat is installed on a raised concrete platform with a wood roof supported by wood posts and with open side walls.

Lime storage shed.—For the preparation of limewater for the CO_2 removal system, lime is stored in a one-story frame building, with concrete foundations and floors, 14 feet wide, 67 feet long, and 15 feet high. This building is adjacent to the railroad siding, with a wide window at the elevation of the box-car floor for the unloading of lime. The lime is wheeled from the lime storage shed up an incline to the mixing platform.

Storehouse.—Spare parts for mechanical and electrical equipment and miscellaneous tools and material are stored in a one-story concrete building, between the separation and compression buildings, 40 feet square and 20 feet high from grade to the top of the parapet wall. This storehouse is equipped with suitable metal shelving.

Heating.—The office and laboratory building, storehouse, pump house, and the toilet and wash rooms of the compression and separation buildings are heated by direct radiation. The compression building is heated by four unit heaters. Steam is delivered by two 150-horsepower boilers, with stacks, installed in the boiler room adjacent to the pump house. The pump-house radiation is supplied with exhaust steam from the boiler feed pumps.

Hot water is provided for the toilet and wash rooms and the office and laboratory building by gas-burning heaters.

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Connections have been provided in the laboratory for hot and cold water, steam, gas, and electricity. A small motor-driven air compressor will be installed as a part of the laboratory equipment.

POWER.

Requirements.—Electrical energy is required to operate motors as prime movers for various mechanical apparatus and for lighting. The power required for motors is computed as 6,475 horsepower for operative purposes, plus 1,965 horsepower for stand-by units. The monthly consumption of energy is reckoned at 2,200,000 kilowatt hours.

Source and characteristics of supply.—Energy is delivered by the Fort Worth Power & Light Co. at a point on the company's transmission line approximately 3 miles from the site of the helium-production plant, from which point the Government has constructed under contract 3800–A, a transmission line to the main transformers at the plant. The energy delivered by the power company is 3-phase alternating current at 60,000 volts and 60 cycles.

Transformers.—The larger part of the equipment is operated at 2,200 volts. Therefore there were purchased four 2,000-kilovolt-ampere 60,000/2,300–2,200-volt General Electric single-phase transformers, of which one is a spare, with complete accessories. Three 200-kilovolt-ampere and three 100-kilovolt-ampere 2,200/440–220-volt single-phase transformers were purchased, to step down the current for the motors for the limewater circulating pumps, the lime mixers, the cooling pond spray and circulating pumps, the well pumps, the fans, and the condensation pump. The lighting supply to the buildings is 3-wire 220–110-volt alternating current, with 110-volt branches carried to the various outlets. A 37.5-kilovolt-ampere single-phase 2,200/220–110-volt transformer has been provided for the lighting. A 7.5-kilowatt constant-current transformer has been provided for the fence lights.

Measurement of supply.—The amount of power delivered by the power company will be measured by a recording wattmeter and the energy by an integrating watthour meter, installed and maintained by the power company on the secondary side of the main transformers. The power factor will be measured by a power-factor meter installed and maintained by the power company on the secondary side of the main transformers. The Government has installed meters to check each of these three meters, and the Government meters are to be conclusive as to the amount of power and energy delivered, in case of the failure of the power company's meters to register.

Cost of power and energy.—A contract has been consummated with the Fort Worth Power and Light Co., providing for the following rates:

(*a*) \$1.50 per kilowatt of maximum demand during each monthly billing period, but not less than \$6,900 per month.

(*b*) \$0.01¼ per kilowatt-hour of energy for the first 120 hours' use of maximum demand during each monthly billing period.

(*c*) \$0.01 per kilowatt-hour of energy for next 120 hours' use of maximum demand during each monthly billing period.

(*d*) \$0.00¾ per kilowatt-hour in excess of 240 hours per kilowatt of maximum demand during each period.

These rates are further varied by a sliding-scale agreement based on company production costs.

Thus, with a maximum demand of 5,400 kilowatts and a monthly energy consumption of 2,200,000 kilowatt-hours, the average monthly cost will be \$29,460, or approximately \$0.01⅓ per kilowatt-hour.

GAS HOLDERS.

Gas-holder capacity has been provided as follows:

Incoming natural gas, two 5,000 cubic-foot holders.

Nitrogen, one 10,000 cubic-foot holder.

Waste gas, one 10,000 cubic-foot holder.

Impure helium, one 5,000 cubic-foot holder and one 10,000 cubic-foot holder.

Pure helium, two 5,000 cubic-foot holders.

The 10,000 cubic-foot holders for nitrogen and waste gas have been furnished and erected under contract. The other holders were removed from the experimental plants, adjacent to the site of the production plant, and reerected at the production plant.

All of the holders are single-lift. The water seals are prevented from freezing by steam pipe coils.

CAPACITY OF PLANT.

The plant is designed for a production of 40,000 cubic feet of helium per day.

CONSTRUCTION COSTS.

The total cost of the helium-production plant and the natural-gas pipe line was approximately \$3,500,000.

OPERATING COSTS.

The plant is operated by the Linde Air Products Co., under the supervision of the Bureau of Engineering, through an agreement whereby the Government shall sustain the operating expenses and pay to the Linde Co. a fee of $2,500 per month.

The Linde Co. has estimated the operating personnel to be paid by the Government as 107 men, and the amount of natural gas to be extracted, absorbed, or dissipated as 10 per cent of that processed.

Based on a production of 40,000 cubic feet of helium per day, or 1,200,000 cubic feet per month, the operating costs may be estimated as follows:

	Cost per month.	Cost per 1,000 cubic feet.
Power (maximum demand 5,400 kilowatts, energy 2,200,000 kilowatt-hours per month)	$29,460.00	$24.55
Gas (16,000,000 cubic feet per month at $0.17 per 1,000 cubic feet)	2,720.00	2.27
Labor (107 men at $160 average)	17,120.00	14.27
Supplies, repairs, etc. (estimated)	10,000.00	8.33
Linde fee	2,500.00	2.83
Total	61,800.00	52.25

CHAPTER XX.

ACTIVITIES OF THE CORPS OF CIVIL ENGINEERS IN THE WEST INDIES.

The endeavors of the Navy Department during the eventful years 1917 and 1918 were not entirely devoted to the customary ends of warfare. The treaty obligations of this Government to Santo Domingo and Haiti were scrupulously carried out, and improvements were made in our new acquisition, the Virgin Islands. The "military governments" were established to conserve the revenues, to develop the country, and to improve the methods and standards of the islands, directing and instructing with the intent of establishing these peoples in their places among the nations of the world.

Since the Navy's work in these islands was constructive, it fell to the lot of the Corps of Civil Engineers to carry out important treaty obligations, at a time when every officer and man was imbued with the martial spirit, and properly so. For this reason a full meed of credit attaches to those members of the corps who cheerfully and efficiently performed the duties assigned them, shut off from participation in the World War, in remote islands where even the news of the great conflict was long in filtering.

SANTO DOMINGO.

In Santo Domingo strenuous efforts were made to improve all means of communication. Most of the roads were formerly impassable except for pack animals, while now there are approximately 100 miles of new macadam roads, with 15 large bridges—7 of steel and 8 of concrete. In addition, there are about 100 miles of second-class and about 200 miles of third-class roads in the country.

Two main trunk highways are under construction. One of these, from the capital, Santo Domingo City, to Monte Cristi, about 175 miles long, is expected to be completed by July or August, 1921. This road unites the north and south coasts of the Republic. The other, running east and west, has been made passable for vehicles for a distance of about 225 miles. Only a small portion of this road is macadamized at the present time.

Railroads, bridges, telephones, sewers, water systems, harbor improvements, lighthouses, and customhouses have been built. Public

buildings throughout the country have been repaired and provided with sanitary equipment. A leper colony, consisting of 40 houses for the patients, a mess hall, laundry, and administration building, has been established.

In November, 1916, no more than 12,000 children were in the public schools; while to-day—through the efforts of the department of public instruction—120,000 children are receiving the education to fit them to become good citizens. To further this work a building program calling for an expenditure of about $1,000,000 has been approved, and construction of schoolhouses in accordance with this program is in progress, some of the buildings being already occupied and many others nearing completion.

The work of the two civil engineer officers, Commander Ralph Whitman and Commander Ralph M. Warfield, successively assigned to supervision of public works in the Dominican Republic, was not confined solely to building operations. The officer now in charge has been assigned by the military governor, Rear Admiral Thomas Snowden, U. S. N., to the secretaryship of state for communications and the secretaryship of state for agriculture and immigration, both cabinet positions in the military government. Commander Whitman was detailed by the then military governor, Rear Admiral H. S. Knapp, U. S. N., as a member of the Dominican claims commission, which passed upon claims amounting to $15,000,000, of great number and varying degrees of complexity.

Prior to June, 1917, nothing had been done along the line of agricultural education. Since that time the work of education has been extended and instruction given to agriculturalists on methods of seed selection, disease eradication in plants, and soil cultivation. An agricultural college has been built and made ready for opening for the education of young Dominicans in scientific agricultural pursuits, as well as for the ascertainment of accurate information on plant diseases under conditions existing in the Republic. School gardens have been planted, and agricultural instruction has been given in connection with education in the various common schools.

By efficient control of immigration (consisting principally of seasonal agricultural labor), by instruction and training of the rural element in improved agricultural methods, by the improvement of all means of communication, such as the construction of roads, rebuilding of telephone lines, and development of a postal system, by the building up of commerce through additional harbor facilities, and by a large building program the Civil Engineer Corps has done its utmost to support the military government in its ultimate object of developing and improving the country and preparing the people for self-government when the occupation shall have served its purpose.

HAITI.

The civil government of the Republic of Haiti has not been displaced by American intervention, the military governor of Santo Domingo acting as military representative of the United States in Haitian affairs and assisting the President of Haiti in an advisory capacity. In this Republic, as in the neighboring Republic of Santo Domingo, the principal works coming before the treaty engineer for design and construction as well as for maintenance and repair were the following:

- Public roads, streets, bridges, and ferries.
- Public buildings and grounds.
- Water supply, sewerage, and drainage systems of cities and towns.
- Rural irrigation, drainage, and flood protection.
- Harbor improvements, comprising wharves, piers, quays, etc.
- Lighthouses, buoys, and other aids to navigation.
- The telegraph and telephone services of Haiti, which are a Government monopoly.
- Topographic, geodetic, geologic, and cadastral maps and charts.
- Inspection and control of existing concessions for railroads, lighting, etc.
- Building regulations.

The President of the United States, in December, 1916, nominated Commander Ernest R. Gayler (C. E. C.), United States Navy, for appointment by the President of Haiti as engineer for public works under the treaty, and upon the arrival of this officer he received a commission from the latter as engineer-in-chief to the Haitian Government, reporting on January 3, 1917.

By the fall of 1918 the number of officers of the Civil Engineer Corps commissioned by the President of Haiti as part of the treaty engineer organization had been increased to eight. Each office and division was operated, so far as possible, with no foreign personnel save the officer in charge.

Upon the arrival of the Americans in Haiti there were practically no country highways in the land, the very complete system of highways which had been constructed by the French colonists prior to 1790 having largely disappeared. As a result, there was very little internal traffic, and most of the carrying of agricultural products was done by pack animals bearing small loads along narrow and uneven trails which did not permit the passage of wheeled vehicles of any description. Highways have now been opened up from the extreme northeast point in Haiti, Ouanaminthe, to Les Cayes, the principal city on the south coast, passing through the important sea-

coast town of Cape Haitien, Port au Prince. Carriage roads have also been opened up through the Plaine of the Cul de Sac to the head of the irrigation system at Bassin General, to the salt Lake Etang Saumatre, which forms part of the boundary line between Haiti and Santo Domingo, and to interior towns.

Similar reconstruction work has been done upon the old French irrigation systems, comprising dams, masonry canals, and earth distributing ditches. Largely as a result of these improvements more and better sugar cane is now being raised in Haiti than ever before in its history.

The telegraph system has been developed, a telephone system installed, and sanitary works have been prosecuted—the latter having already resulted in a marked reduction in the sick rate and having improved the appearance of the towns.

The public works office has trained its native personnel in highway and general engineering, so that the Corps of Haitian Engineers has been built up to a total of 30 men. The character of their service has proved quite adequate to requirements.

VIRGIN ISLANDS.

Immediately after the appointment, in February, 1917, of Rear Admiral James H. Oliver, U. S. N., as first governor of the newly purchased Danish West Indies, it became evident that an officer of the Civil Engineer Corps was needed on his staff, and Lieut. Commander Gaylord Church (C. E. C.), U. S. N., was soon ordered to the islands.

The conditions, administrative and physical, were far from encouraging. There were no typewriters in any government office, and the method of accounting was so involved that three years were required before a final settlement in the transfer could be accomplished.

A severe hurricane had occurred in the preceding year, and many of the schools were demolished, as well as one hospital; roads, streets, and parks suffered severely.

The process of reorganization along American lines was slow and discouraging at first. Upon the relinquishment by the former Danish civil engineer of his appointment as building inspector, the new naval civil engineer was assigned to the position. It was necessary for him to sit on the various committees and to try as diplomatically as possible properly to direct their activities. As these committees were usually composed of from five to seven members, the new building inspector's occasions for tact can be imagined.

The public works officer's greatest difficulty was with his surveys. His predicament can be understood when it is realized that all

records and even the printed forms necessary to issue for land transfers were in Danish, that his only surveying instrument was an antiquated Danish one, and that the land records were in journal form and ran all the way back to the eighteenth century.

A naval station was established, new radio towers erected, and a refrigerating plant installed. The public buildings were gradually repaired, and steps are now under way for the erection of several new school houses and for the equipping and installation of an adequate poorhouse and farm on the island of St. Croix. Funds have not been available for even the beginning of a water or sewerage system, but hope is entertained that with Navy Department funds a supply of water may eventually be obtained for the naval station, and that the city of St. Thomas may be supplied from this source, in part at least.

Although no engineering enterprises of any magnitude have as yet been undertaken, the character of the work consisting mostly of minor repairs, nevertheless the reorganization and administration of public-works activities have covered a wide range of subjects, and have been unique in this respect as an undertaking for a representative of the Bureau of Yards and Docks. Though out of the war zone and undisturbed by the great struggle of the World War, the activities in connection with the civil government were most interesting, and tried to the utmost the ingenuity of the public works officer. There prevailed a diversity of operations ranging from surveying a 100-acre property to measuring for floor tax all floors in a 30 by 30 foot house; from installing a town clock in the courthouse tower to inspecting a leper asylum of 60 inmates or an insane asylum of 20 patients; from the placing of "white wings" on the city streets to settling a strike of grave diggers before a funeral; from diplomatically handling a committee of the Colonial Council to settling labor friction by employing the chief agitator in a foreman's capacity; and though all these presented no grave engineering difficulties, they were interesting enough to require the utmost exertion from the civil engineer, and it was with satisfaction that he saw emerge from chaos a smooth-running, well-organized department, a credit to the naval government in control, and having the loyal support and hearty approval of the native population, who at first looked with suspicion upon each innovation.

CHAPTER XXI.

CONSTRUCTION DIVISION OF THE BUREAU.

CONTRACT SECTION.

Contracts.—From April 6, 1917, to November 11, 1918, the period of the war, proposals for public works were opened at the bureau for approximately 841 separate projects, while proposals for approximately 439 additional projects were opened at the several yards and stations and the bids forwarded to the bureau for action. From this total of bids received, 1,016 awards, totaling approximately $120,000,000, were made, the balance of the bids being rejected. The largest number of rejections occurred during armistice time. For the week of November 4, 1918, the bureau carried 41 projects on which no action had been taken; there were 23 openings and 3 rejections; for the week of November 11 there were 53 projects not acted upon, 26 openings, and 6 rejections; for the week of November 16 there were 52 projects not acted upon, 16 openings, and 20 rejections; for the week of November 23 there were 23 projects not acted upon, 20 openings, and 10 rejections; while for the week of November 30 there were 23 projects not acted upon, 18 openings, and 1 rejection.

In practically all cases, plans and specifications were prepared, and the work was regularly advertised prior to the openings of proposals. Bids were opened weekly, generally on Wednesdays at 11 o'clock, except when simultaneous openings were held at the bureau and at the yard concerned, when, owing to differences in time, a corresponding hour for opening would be set for the bureau. Proposals not accompanied by certified checks, as required by the specification, were declared informal and returned to bidders. Occasionally certified checks totaling nearly $1,000,000 would be received at a single opening. Checks for $50,000 were not uncommon, and $75,000 checks were required on one opening, the largest check ever required being for $85,000.

The bureau also awarded approximately 100 contracts for emergency work on the basis of actual cost plus a percentage. These contracts involved approximately $60,000,000, for which no proposals were requested, owing to the urgency of the work. Great care and discrimination were used in placing these contracts to secure the services of thoroughly reliable and responsible contractors.

After recommendation of award had been made by the project managers to the contract section, and prior to award, the bids were submitted to the priorities committee of the War Industries Board for clearance. No awards were made until cleared. This procedure was necessary in order to eliminate, or postpone, the construction of any unnecessary work.

Coincident with the declaration of war, authority was delegated to the chief of the bureau by the Secretary of the Navy to make awards and sign contracts for the department. This was done in all cases except cost-plus contracts, which were awarded and signed by the Secretary.

It may be interesting to note in passing that in comparison with the above figures the bureau for the fiscal year ending June 30, 1917, which period included the first three months of the war, awarded 172 contracts, involving approximately $30,000,000, of which sum approximately $12,000,000 was for work awarded on a cost-plus-percentage basis, divided into approximately 25 contracts. These contracts covered nearly all the emergency training camps, which were constructed under the first cost-plus contracts awarded. For the fiscal year ending June 30, 1916, the bureau awarded 79 contracts, involving approximately $1,840,000; and for the fiscal year ending June 30, 1915, 84 contracts, involving approximately $1,951,000.

During the war period the bureau also entered into 128 supplemental agreements covering extra work and involving approximately $10,000,000 additional.

In all cases, except where work was awarded on a cost-plus basis, bids were opened by the bureau in the presence of bidders, and awards, when made, were made to the lowest bidder. Bids were required in duplicate. A bound copy of all papers received at openings, together with a list of bidders and the amount of each bid, was retained in the bureau files, properly indexed, for future reference. In addition, a contract-record book was kept, stating in each case the specification number and date of assignment of such number; title and location of project; name of project manager; whether bids were opened at the yard or at the bureau; estimated cost of work; date of opening; date and amount of award; time for completion; name and address of successful bidder; all data pertaining to the signature and return of contract and bond and to the distribution of copies to parties concerned; and the date of receipt by the contractor of his copy of the contract, which date marked the official time from which to compute the contract date for completion of the work. This copy was forwarded by registered mail, in order that the bureau might have on file the registered return receipt card as evidence.

Several indexes were maintained: A cross-card index of contracts and contractors; a visible index of completed, uncompleted, rejected, and canceled projects, classified by yards and stations; a current index of all contracts by yards and stations, on thin white paper (carbon backed), for blue printing, showing work completed and in progress, with the present status of the latter, and giving total costs to date. This latter index was established, and is still maintained, as a basis for preparation of annual reports of the contract section for the chief of the bureau. With but three or four exceptions, all contracts were drafted and typed by the contract section, and all final decisions in connection with their adjustment and settlement were made under bureau authority.

A penal bond in a sum equal to 30 per cent of the contract price was required by the bureau on all public works contracts except those awarded on a cost-plus basis. On cost-plus work the bureau fixed the amount of the bond at 5 per cent of the contract price.

Bonds were furnished with either a corporation or individuals as sureties, a stamp tax of 1 per cent of the amount of the premium charged being required on corporate bonds, and a 50-cent stamp on personal bonds, unless a charge was made for its execution, in which case stamps totaling 1 per cent of the amount of the premium charged were required as on corporate bonds. The largest single stamp received was one for $500.

Late bids for work were accepted when it was evident from the postmark on the envelope that the bid had been mailed in reasonable time to reach the bureau by the hour set for the opening. Bids forwarded to the bureau by registered mail, whether having a special-delivery stamp affixed or not, were greatly delayed in delivery. One bid mailed at Buffalo, and plainly postmarked, reached the bureau eight days after mailing. This was due entirely to congestion in the Washington registry office, an investigation showing that this office, equipped to handle a normal receipt of 5,000 packages daily, was occasionally called upon, during the war period, to handle 50,000 packages per day.

Changes.—Under lump-sum contracts, changes, involving additions to, deductions from, or substitutions in the work originally contracted for, were deemed desirable and occurred with greater or less frequency as the requirements unfolded on the site of projects. In the more flexible contract types, such as the unit-price and cost-plus forms, the issuing of formal instructions by the bureau and the fixing of a definite price for changes were not so essential to compliance with the terms of the contract as in the first-mentioned type, since payment for the changes could be made without the issuing of what is known as a "change order." A change order, however, was necessary for each modification in any contract of the lump-sum

type. Copies of such orders, besides being sent to the contractor, were forwarded to the Auditor for the Navy Department, the public works and disbursing officers at the yard or station concerned, the bondsmen, and those within the department who required them for the purposes of accounting and record.

Adjustments.—Early in April, 1917, the steel trade, through the American Iron and Steel Institute, agreed to supply the Navy's requirements (up to a certain fixed tonnage) at the special Government prices of 2.5 cents per pound for reinforcing rods, bars, and shapes, and 2.9 cents per pound for plates, both figures being base prices, f. o. b. Pittsburgh, Pa. These were considerably lower than the prices then prevailing. The bureau immediately began requiring of all bidders the steel quotations upon which their offers were predicated, and inserted adjustment clauses in the contracts. Upon an award being made, the tonnage requirements were obtained from the contractor and transmitted to the American Iron and Steel Institute, who in turn allocated the orders where they could best be filled. The contractor was immediately instructed by the bureau as to the mill or mills from which to obtain the steel, as well as the price to be paid, and advised him concerning the rate of credit accruing to the Government. This credit was, in all cases, the difference between the base prices used by the contractor in his proposal and the Government prices; the card extras for cutting, bending, and size and the freight not entering into the adjustment, since they would have been the same in any case. At times, when it became apparent that delay on the part of the mills in delivering the steel according to schedule would have seriously retarded the progress of the work, the bureau authorized purchases for immediate needs from stock at an advanced price. This necessitated the calculation of a different set of adjustment figures. The bureau kept in close touch at all times, through the American Iron and Steel Institute, with conditions at the mills furnishing steel to Navy contractors and with the locations and prices of stock or warehouse material. As a result, very few delays on account of the steel situation occurred, and advantage was taken of the lowest warehouse prices.

In the latter part of September, 1917, just after the Navy's tonnage agreement had been fulfilled, the base prices were raised by the War Industries Board, which had shortly before begun to function, to 2.9 cents per pound for reinforcing rods and bars, 3 cents per pound for shapes, and 3.25 cents per pound for plates, all f. o. b. Pittsburgh. This required still another set of adjustment figures. In December, 1917, the cost of stock steel was fixed and agreed upon by the Navy, in conjunction with the War Industries Board, at 1 cent per pound over that of mill material, whereas previous to that time it had been costing from 2 to 7 cents per

pound more. This resulted in a considerable saving in money and time, and reduced the number of protests and discussions as to the proper allowances to be made. A close touch was still kept, however, with the locations and character of the manufacturers' stocks. Later, when the selling prices of steel as fixed by the War Industries Board became generally known to contractors, few adjustments had to be made, particularly when the bid stated that the fixed prices had been used.

All adjustments were made by the public works officer upon the completion of the work. In some instances, these adjustments operated to increase the contract price, especially when the contractor bid on the special Government prices and was instructed, because of the small quantity required, to obtain from stock. Cases such as this, however, were very rare. On steel adjustments, several hundreds of thousands of dollars were saved to the Government by this bureau alone.

In a similar fashion, in June, 1917, arrangements were made with cement companies whereby the Government obtained special prices. On this commodity, however, the Navy actually purchased the material, storing it at the several yards. It was parceled out to the contractors as it was needed, and the contract price was reduced by the product of the bid price for cement delivered at the site times the actual quantity used. A reduction was made on each monthly voucher for payment, according to the quantity used during the month. Due account was taken of sacks not returned, and of those returned but rejected by the mill as unfit for further use. As the bureau obtained the cement in large quantities, the special prices were approximately 25 cents per barrel less than the prevailing market prices. This resulted in a saving of thousands of dollars to the Government, through the operations of this bureau individually. There were at all times sufficient quantities on hand to keep contractors supplied, and the aggregate of time thus gained was, in all probability, very great.

Expediting.—The contract section in the early stages of the war, before the priority system was put into operation, assisted as much as possible in expediting the delivery of manufactured articles to contractors by writing letters and sending telegrams explaining the urgent need of the completion of the contract. This correspondence in most cases had the desired effect, and supplies were obtained more quickly than if such action had not been taken. At the same time, a tracer system on shipments was adopted, which, after the car initial and number, its routing, the place and date of shipment, the commodity, the consignee and consignor, the bill-of-lading number, etc., had all been obtained, located cars and expedited them to destination. During the railroad congestion this work was invaluable to con-

tractors, and the Government benefited by obtaining the completed work sooner than would otherwise have been possible.

INFORMATION AND PLANS.

At the time of the functional subdividing of the Design Division, it was felt that information relative to the status of projects should be obtainable at a single point. This was considered necessary not only as a matter of convenience to bidders, materialmen, and trade representatives in general, but also as a means to obviate numerous inquiries which would have seriously encroached upon the time of the various project managers and have handicapped them in the execution of their rapidly multiplying duties. To accomplish this result a new office, designated the "information section," was established under the Clerical Division, but it was transferred after a short period to the Construction Division, to which it was realized the duties more properly related. A change in name to the "plan section" was effected. Methods presented themselves for recording and keeping conveniently on open file the several classes of data, as follows: (a) Lists of projects contemplated; (b) records of projects under advertisement; (c) copies of drawings and specifications; (d) lists of prospective bidders; (e) briefs of bids received; and (f) records of awards of contracts.

Cognizance over the plan files of the bureau is placed with this office. Since the declaration of war 30,000 drawings have been recorded and filed.

All completed specifications and proposed addenda are submitted to the chief of the bureau for approval through this section. This approval carries with it authority to advertise and to issue the bidding data to interested parties.

In view of the fact that over 75 per cent of the bureau's blue printing was, and is, for the purposes of issuing drawings to prospective bidders, such work was naturally placed under the cognizance of this office. As the work increased and as contractors were compelled to seek Government contracts because of the lessening of commercial work, the capacity of the duplicating facilities of the bureau and of the commercial firms having annual contracts became so sorely taxed that the "deposit system" was inaugurated.

A scale of deposits was established, varying in amount with the bulk of bidding data pertaining to a project, without reference to the estimated cost of the construction involved. Checks or money orders were required in the following amounts: $10 for 10 drawings or fewer, $20 for 11 to 20 drawings, $30 for 21 to 30, and so on up to $50. Where more than 50 drawings pertained a deposit of $100 was required, which was also the maximum. A copy of specifications was included with each set of plans.

After award of contracts, deposits were not released until the several parcels of bidding data were returned to the bureau, except in the case of the successful bidder, whose deposit was automatically returned.

The maximum deposit was required on several projects involving a large number of buildings, notably the training camps; but in by far the greatest number of instances a $10 earnest covered the data furnished.

The above scheme of charges practically limited the issue of drawings and specifications to parties directly interested, and resulted in a net saving of about 40 per cent in the amount of blue printing.

INSPECTION SECTION.

Under the organization of the Construction Division, of November, 1916, all matters of inspection were handled by one assistant, with the part-time assistance of a stenographer. In the early part of 1917 various filing systems and indexes were established to facilitate the handling of the work, and these readily expanded under the later inundation and proved invaluable.

Inspection of all engineering materials, such as structural steel, motors, turbines, pumps, pipe, etc., which require special tests or examination at the point of or during process of manufacture, is under the cognizance of this section, whether such materials pertain to public works contracts or supply contracts.

The bureau maintains no inspection force directly, but utilizes the services of inspectors of engineering material and inspectors of machinery, under the Bureau of Engineering; timber inspectors, under the Bureau of Construction and Repair; and experts of the Bureau of Standards, under the Department of Commerce.

As a result of war-time expansion, a separate bureau inspection organization was created, which engaged, at the peak of operations, two male assistants, one typist acting on part time as file clerk, and three stenographers.

Field forces increased in like proportion, and as an indication of the volume of work performed it is of interest to note that three assistant inspectors were employed on full time in Detroit, solely for the inspection of motor vehicles bought under the cognizance of this bureau. Another interesting activity arose in connection with the procuring of secondhand locomotive cranes. The competition for such equipment became so great that the use of letters gave way to that of telegrams, and finally it became necessary to instruct the approximately 600 assistant inspectors in the field to keep on the alert for cranes wherever they might be found, and if one was located which appeared to be suitable, to obtain certain specified facts, such as capacity, length of boom, wheel arrangement, age, etc., and then to report at once, by telephone, to the chief inspector at the bureau.

37022—21——30

A list of requirements was on file, in tabulated form, and if the assistant inspector's information indicated that the crane in question would fit any request on the list he was instructed to notify the owner orally that same was commandeered, and to remain in attendance until the Bureau of Supplies and Accounts could send the telegraphic notice of commandeer. Such notice was on the wire, in several instances, within two hours of the time of the receipt of the assistant inspector's message.

Other functions which were, and are now, under the cognizance of the inspection section, include the procuring and filing of monthly reports under contracts and yard allotments, progress photographs, and schedules of anticipated progress; and the procuring of piling reports, hydrographic reports, subsurface reports, etc.

Monthly reports on contracts are made on cards 5 by 8 inches in size and show all pertinent data as to progress. They are filed in a visible-index device of the vertical pocket type.

Monthly reports on work under allotments are similarly prepared and filed.

Construction photographs are exceedingly important for the proper following up of projects by the bureau, and such photographs are required monthly on all contracts and also on all major work under allotment. These are indexed by yards and stations, and under 36 subheadings according to the use required of the several structures. All prints are filed in cloth-mounted envelopes, which are lettered on the face to correspond to the cards of a separate index file.

Schedules of progress are secured from contractors at the beginning of work, in order to ascertain their expected progress on all major items which go to make up their completed jobs. Such documents are of value to the bureau in keeping a check on the actual prosecution of work, and also in connection with contractors' claims for extensions of time.

Piling reports are secured from public works officers, and afford pertinent data concerning the driving of all piles, showing such details as weight of hammer, height of fall, size of pile at butt and point, penetration, number of blows required to seat, etc. These data are listed in tabulated form and are accompanied by a key diagram. Such information affords an insight into foundation conditions at various points throughout a yard, and is of importance to the bureau for that reason, among others.

Hydrographic reports are secured from yards quarterly, semiannually, or annually, as conditions of bottom dictate, and show the depth of water in all berths and slips.

Subsurface reports are received from yards quarterly, and furnish information as to any underground service which has been extended during the period.

CHAPTER XXII.

MAINTENANCE AND OPERATION DIVISION OF THE BUREAU.

A division known as the Maintenance, Operating, and Clerical Division, under the direction of the chief clerk of the bureau, was established by a bureau order, dated March 26, 1917, and was superseded, under bureau order No. 121, August 6, 1917, by the Maintenance and Operating Division, under the direction of Mr. William M. Smith, special assistant, formerly chief clerk.

The duties assigned to the Maintenance and Operating Division were as follows:

1. Financial accounts and records.
2. Annual estimates.
3. Navy yard personnel (clerical and technical).
4. Requisitions.
5. Furniture records.
6. Officers' quarters.
7. Navy yard transportation facilities.
8. Navy yard communication systems.
9. Public works data book (confidential).
10. Book of yard maps (confidential).
11. List of stations (confidential).
12. Accounting system at navy yards and job orders.

(1) *Financial accounts and records* includes the keeping of obligation and expenditure accounts of all appropriations under the cognizance of the bureau; the determining and making of regular and special allotments from annual and special appropriations; examination of reports of expenditures and making proper entries therefrom.

(2) *Annual estimates* includes the calling for, getting in, and tabulation of annual estimates for public works and other Yards and Docks appropriations; arrangement of explanatory data for convenient examination and action; securing comment of interested bureaus or offices; keeping record of action taken on each item; preparation of explanatory statements for Secretary or congressional committees.

(3) *Navy yard personnel* includes determining upon the number, rating, and pay of technical and clerical employees at navy yards and stations under the cognizance of the bureau; securing authorization of necessary positions and selecting eligibles for appointment; consideration of recommendations for promotions, reductions, or dismissals; provision of necessary facilities for health

and comfort of men; interviews and correspondence concerning appointments and promotions.

(4) *Requisitions* includes the examination of requisitions from yards and stations and keeping record of receipt of and action on same; determining the necessity for materials or articles required for; the legal availability of appropriations proposed to be used; reasonableness of estimated costs and proposed time of deliveries; consideration of bids referred to the bureau for action; arranging inspection in special cases, consideration of changes in orders, and matters of shipment and delays.

(5) *Furniture records* includes determining proper allowance of furniture for officers' quarters and offices; selection of designs; placing of orders; keeping record of furniture on hand; consideration of surveys covering repairs and replacements.

(6) *Officers' quarters* includes determination of necessity for repairs and alterations to officers' quarters and keeping record of occupants and assignment of quarters.

(7) *Navy yard transportation facilities* includes determination of the necessity for equipment and the type, capacity, and number of various facilities or articles, such as locomotives, cars, locomotive cranes, motor trucks, passenger-carrying vehicles, railroad and crane tracks, horses and mules, garages, stables, roundhouses, etc.; keeping a record of equipment on hand; consideration of surveys covering repairs and replacements.

(8) *Navy yard communication systems* includes determination of the type and extent of telephone, telegraph, tube, and other systems of communication at navy yards; making of necessary contracts for service; surveys covering repairs and replacements, etc.

(9) *Public works data book* (confidential) includes the keeping up to date of the data book, "Public Works of the Navy" (loose-leaf system), covering miscellaneous data concerning all places under the jurisdiction of the department, details of land, facilities, dry docks, coaling plants, and structures of all kinds, showing their size, character, age, cost, etc.; preparation, printing, and distribution of corrected pages.

(10) *Book of yard maps* (confidential) includes the preparing and issue at suitable intervals of maps of navy yards and stations, also the procuring and filing of plot plans of all land under the control of the Navy Department.

(11) *List of stations* (confidential) under Navy Department includes the preparing and issuing, periodically, of lists of stations and places owned or rented by the Navy Department.

(12) *Accounting system* includes all matters relating to accounting system at navy yards and examination of job orders.

The clerical section was at the same time transferred to a newly organized clerical division under the direction of the chief clerk (see chap. 1).

FINANCIAL ACCOUNTS AND RECORDS.

While the Bureau of Supplies and Accounts is charged with the duty of keeping the accounts of expenditure of the Naval Establishment, it has always been necessary for the Bureau of Yards and Docks to keep obligation accounts of its many appropriations in order to know in advance what funds were free of incumbrance for each authorized project or purpose, and to determine whether the

cost of work was kept within the approved allotment of funds therefor.

The system of handling funds placed under the cognizance of the bureau by the appropriation acts is known as the allotment system, which is in effect an extension of the appropriation system. Congress makes appropriations by which it places at the disposal of the chief of the bureau a certain sum of money for a certain purpose or a certain class of objects. The bureau, in turn, by making allotments, places at the disposal of the officer, charged with the execution or performance of the project or job, a sum of money for the purpose. Each appropriation made by Congress for the use of the bureau, and each allotment made by the bureau for the use of the navy yards and stations, constitutes a separate and distinct debit and credit account. Under the law, appropriations can only be expended for the specific purpose for which they are made, and, by bureau order, the same rule applies to allotments. Accurate accounting is therefore essential to prevent overexpenditures and misapplication of funds.

At the beginning of the war this system was in effect. It was foreseen that there would be a sudden and enormous increase in the number of accounts to be handled, due to war conditions and the necessity of knowing more promptly the condition of all accounts. In order that the sufficiency of the system to meet the approaching conditions might be definitely established, or another system adopted if necessary, the bureau secured the services of a firm of expert accountants, who made an exhaustive study of the system and its operation, and found it sufficiently elastic to absorb any increase in volume of work that might result from war conditions. The largest number of open accounts was carried during the first part of 1919, when there were 497 appropriation accounts and 15,379 allotment accounts active. These covered the accounting for approximately $342,000,000, and were successfully handled by a force varying from two to eight bookkeepers and clerks.

Every effort was made by the bureau to impress upon all officers and others charged with the expenditure of funds the necessity of exercising care to prevent any excessive or improper expenditure and of keeping proper record of all financial transactions. The tendency toward extravagance and disregard of formalities attending the expenditure of money in cases of emergency is always strong, and as the emergency was very great, the bureau felt it advisable to issue warnings from time to time as reminders to those executing the orders of the department that eventually a full accounting would be expected.

Early in the war period a placard was issued reading as follows:

MONEY

You can not get work done without money. You can not get money except from Congress, through the department.

The department can not give you money unless it has been given money by Congress for the purpose for which you want it.

You have no right to spend money which has not been allotted to you by the office or bureau to which it has been given by Congress.

You have no right to overdraw your account.

If you want money, ask the man who has it and tell him why.

If you want anything that costs money, get the money first.

If you are in a hurry, say so, and ask for credit till you can get the money.

Don't incur an obligation you are not prepared to meet, and don't ask anyone to do so for you.

Money is needed to win the war—don't ask for it for any purpose which does not contribute to that end.

Every penny must be accounted for.

You will be asked what you did with what was given you.

Hang this where you can see it every day—and read it—it will help you.

Don't think because you do not handle the cash that you need not bother about the money—where it comes from or how much is spent.

COOPERATE—We are all working toward the same end. Help those who must get money from Congress—help those who must pay it out—help those who must account for it—think of your coworkers and try to help them.

ANNUAL ESTIMATES.

The annual estimates prepared by the bureau consist of those covering the annual appropriations for bureau salaries, maintenance of navy yards and stations, repairs and preservation of the property of the Navy ashore, contingencies, and the specific appropriations for the construction of new public works. The volume of the work involved in the preparation and submission of these estimates during the war period did not greatly increase, for the reason that war

expenditures were mostly made from large lump-sum appropriations placed at the disposal of the Secretary of the Navy. No increase in force was necessary to handle this item of the work of the division.

NAVY YARD PERSONNEL.

The sudden activity resulting from the declaration of war required a large increase in the technical, clerical, messenger, and civilian police forces at the various navy yards and stations. Early action was taken to secure data indicating the probable requirements in this respect and to provide through the regular channels the necessary personnel promptly upon call. The result was fairly satisfactory, notwithstanding the great difficulty in securing competent employees without calling to such work men qualified for military service, or otherwise interfering with the more important work of the war. By close cooperation with the Civil Service Commission the bureau was able to have practically all appointments made in strict accordance with the law and regulations governing the civil service, and thus to avoid complaints and controversies.

REQUISITIONS.

The requisitions involved under this heading are those covering the purchase of materials and supplies, or the procurement of services by contract, for jobs of a minor character, under funds provided for the work under the cognizance of the bureau at the various navy yards and stations. These ranged in importance, judged by the amount involved, from a few dollars to nearly $1,500,000. Requisitions are prepared on a prescribed blank form at the navy yard or station where the material or services are required, except in special cases, as where the bureau prepares a requisition covering articles or material to be delivered to various places. The form sets forth by items the material required, and indicates when and where it is to be delivered, where it is to be inspected, the appropriation and particular account to which the expense involved is to be charged, and other pertinent facts necessary to enable the purchasing officer to secure competitive proposals and make award, arrange inspection, and have delivery made. Upon receipt of a requisition by the bureau a record of its receipt is duly made, after which a number of questions arise. Has the requisition been properly prepared? Is it signed by the proper official? Does it show the particular account to be charged? Are sufficient funds available under such account? Are the quantities called for reasonable or excessive? Are they suitable for the purpose? Could any material in stock be used instead of buying that requested? These and at times other questions require

a most thorough and careful consideration of every requisition handled by the division by employees possessing excellent judgment and a considerable degree of technical knowledge and experience. From April, 1917, to July, 1919, 36,721 requisitions were received and 28,676 were approved. From time accounts kept at various times it was found that 1.2 minutes of the time of the head of the division was required to visé and sign each requisition after it had been checked and made ready for signature. Upon this basis, and counting 7½ hours to a day, approximately 130 days of the period of 730 working days reported upon, or approximately 18 per cent, were devoted to this work by the head of the division.

In addition to the handling of the requisitions as stated above, the requisition section also handled such of the bids made for furnishing materials and supplies as were referred to the bureau for recommendation by purchasing officers, and arranged for the inspection of the materials and supplies purchased on the requisitions where inspection at the place of manufacture was desired.

FURNITURE RECORDS.

The bureau is charged by law and regulations with providing furniture for Government houses and offices in navy yards and naval stations. All officers of the Navy, except midshipmen, are entitled to have furnished quarters provided for their occupancy or to be paid commutation therefor if quarters are not provided. At the beginning of the war, 289 sets of officers' quarters were available for use, furnished in accordance with the established allowance. This allowance covers four classes of quarters, namely, commandants', commissioned officers', bachelor officers', and warrant officers', and has been arranged with a view to providing furnishings in every way commensurate with the needs and standing of the service, durable and of good quality, without being elaborate. Prior to the war the average cost of furnishing a typical set of quarters was $1,200. At the present time articles are costing approximately three times the former prices.

During the war a great many temporary quarters, largely bachelor quarters of one or two rooms, were provided and furnished, principally at temporary training camps and section bases. When these activities ceased after the signing of the armistice the furniture was turned into store and reissued from time to time as required to replace worn-out furniture in the permanent quarters, which had increased to 411 in number. In this way the loss which would have attended the sale of slightly used articles was avoided.

The very large increase in office personnel during the war necessitated the purchase of large quantities of office furniture, principally

desks and chairs, from time to time. Records of such furniture were maintained at the various navy yards and stations but not at the bureau.

Upon the curtailment of activities after the signing of the armistice, all serviceable office furniture was stored for future issue except in a few cases where comparatively small quantities were transferred to other departments of the Government or sold to the new occupants of rented offices in order to avoid the expense of moving. Articles which had been damaged or much worn in use were surveyed and sold in the usual manner.

OFFICERS' QUARTERS.

As before stated, all officers of the Navy excepting midshipmen are entitled by law to have quarters provided for their occupancy when serving "with troops," which means, practically, when on active duty ashore. From the earliest days of the Navy it was the practice to provide living quarters in the various navy yards for the commandants and other officers whose duties made it essential that they be present at the yard at all times and available for instant duty in cases of emergency. The same rule still applies, and quarters are provided, not as a matter of convenience or comfort for the officers, but for the benefit of the Government and as an essential element of military discipline and protection.

The available quarters for officers are assigned according to the relative importance of the presence of the officers at the yard at all hours, without regard to their rank.

At the beginning of the war 289 sets of quarters were available under the cognizance of the bureau; during the war period 122 sets were provided.

A record is kept in the bureau of the name, rank, and duty of the occupant of each set of quarters and the dates of occupancy and release.

A per annum allowance of funds for repairs and alterations of quarters is provided as follows:

	Number of chambers.						
	2	3	4	5	6	7	8
Commandant			$350	$380	$410	$430	$450
Commissioned officer		$250	270	290	300		
Warrant officer	$150	170	180				

An additional allowance of 20 per cent of the amounts above stated is made for necessary repairs incident to each new occupancy.

NAVY YARD TRANSPORTATION FACILITIES.

The principal equipment required to meet the transportation requirements of the navy yards and stations includes locomotive cranes for the handling of heavy weights in transit, locomotives, railroad cars, motor trucks and trailers, passenger-carrying automobiles, motorcycles, bicycles, tractors, horses, wagons, etc. Ample equipment of this character in time of peace is important as an economic feature; in time of war it is a military necessity. The problem of transportation was one of the greatest of the war, and it was so regarded by the bureau and given the most careful and constant attention.

On June 30, 1916, the nine navy yards were equipped with 56 locomotive cranes, 25 locomotives, 175 horses and mules, and 26 horse-drawn passenger-carrying vehicles. No motor trucks nor passenger automobiles had been provided up to this time.

Realizing the inadequacy of this equipment for war-time activities, the bureau took steps in August, 1916, to provide motor trucks for the navy yards, and the following month further steps were taken to provide 10 passenger automobiles. In March, April, and May, 1917, requisitions were made for 31 locomotive cranes, which were to be distributed to the various navy yards and stations. These cranes were secured at prewar prices, as they had been or were being manufactured under prewar conditions of the labor and material markets. Shortly afterwards, as the war requirements developed, the manufacturers of locomotive cranes were overwhelmed with orders, which far exceeded the normal combined capacity of their plants, and it became necessary for the War Industries Board to allocate the product of the plants to the various activities of the Government according to the importance of their requirements with reference to the paramount problem—the winning of the war.

The bureau was complimented by the head of the crane section of the War Industries Board upon its foresight in having provided for its most urgent needs in advance of the general demand, and was congratulated upon having saved to the department a very substantial sum by securing prewar prices upon this equipment.

In April, 1917, requisition was also made for additional locomotives, flat cars, box cars, motor trucks of various sizes, passenger automobiles, and horse-drawn carts, wagons, and lumber trucks.

Throughout the war period the bureau adhered to the manufacturers' standards in the purchase of transportation equipment and found no necessity, or even desirability, of undertaking to standardize the products of the various makers. This was partly due to the fact that the requirements were mostly of a commercial nature, or of such character that the commercial product could be easily and inexpen-

Typical yard 7-ton back-dumping truck.

Typical yard motor street-sweeper.

Typical yard crane-truck handling life raft.

Typical yard crane truck for heavy weights.

sively converted for special service when required. It was believed. also, and found from subsequent experience to be true, that manufacturers took much pride in having their standard product used for war service, and were not only willing but eager to follow it in the service and see that it operated efficiently and satisfactorily. This feeling on the part of manufacturers was of great assistance in promptly securing spare parts for repairs and expert advice when needed.

A comparative statement of the transportation equipment at the navy yards, showing the equipment on hand at the end of each fiscal year from 1916 to 1920, inclusive, illustrates the growth of the transportation systems during the war period. Where no figures are given, data are not available.

Comparative statement of transportation equipment at the navy yards at the end of fiscal years 1916 to 1920, inclusive.

Yard.	Equipment.	1916	1917	1918	1919	1920
Portsmouth	Locomotive cranes	3	7	7	8	8
	Locomotives	2	2	3	3	3
	Railroad cars	......	......	12	12	12
	Horses and mules	10	10	13	10	10
	Passenger vehicles (horse)	3	4	2	0	0
	Passenger vehicles (motor)	0	1	4	2	5
	Motor trucks	0	......	12	14	14
Boston	Locomotive cranes	8	10	11	15	32
	Locomotives	3	4	4	4	6
	Railroad cars	......	......	40	56	31
	Horses and mules	21	20	19	18	17
	Passenger vehicles (horse)	3	3	3	1	0
	Passenger vehicles (motor)	0	2	4	5	13
	Motor trucks	0	......	11	24	41
New York	Locomotive cranes	13	16	25	30	31
	Locomotives	5	8	11	11	13
	Railroad cars	......	......	80	138	131
	Horses and mules	31	30	31	29	33
	Passenger vehicles (horse)	3	2	2	0	0
	Passenger vehicles (motor)	0	9	14	14	7
	Motor trucks	0	......	78	152	51
Philadelphia	Locomotive cranes	10	14	22	44	46
	Locomotives	3	6	8	13	16
	Railroad cars	......	......	33	81	71
	Horses and mules	21	25	25	26	23
	Passenger vehicles (horse)	5	5	0	0	0
	Passenger vehicles (motor)	0	3	15	28	42
	Motor trucks	0	......	44	101	105
Washington	Locomotive cranes	1	5	10	13	21
	Locomotives	0	3	4	4	5
	Railroad cars	......	......	25	27	28
	Horses and mules	5	2	2	2	0
	Passenger vehicles (horse)	2	2	2	0	0
	Passenger vehicles (motor)	0	5	7	10	12
	Motor trucks	0	......	43	52	83
Norfolk	Locomotive cranes	6	......	8	34	34
	Locomotives	2	......	6	9	7
	Railroad cars	......	......	64	111	105
	Horses and mules	26	......	30	41	41
	Passenger vehicles (horse)	3	......	0	0	0
	Passenger vehicles (motor)	0	......	8	8	8
	Motor trucks	0	......	71	83	82
Charleston	Locomotive cranes	4	6	8	14	14
	Locomotives	3	3	3	3	4
	Railroad cars	......	......	23	30	17
	Horses and mules	13	12	10	13	13
	Passenger vehicles (horse)	4	4	0	0	0
	Passenger vehicles (motor)	0	2	5	22	21
	Motor trucks	0	......	17	36	35
Mare Island	Locomotive cranes	6	9	13	16	20
	Locomotives	5	6	7	7	7
	Railroad cars	......	......	52	58	57
	Horses and mules	40	37	42	43	51
	Passenger vehicles (horse)	2	2	0	0	0
	Passenger vehicles (motor)	0	1	4	6	6
	Motor trucks	0	......	33	32	43

Comparative statement of transportation equipment at the navy yards at the end of fiscal years 1916 to 1920, inclusive—Continued.

Yard.	Equipment.	1916	1917	1918	1919	1920
Puget Sound	Locomotive cranes	5	5	5	14	14
	Locomotives	2	2	5	5	5
	Railroad cars	....	....	110	107	82
	Horses and mules	8	8	8	....	2
	Passenger vehicles (horse)	1	0	0	0	0
	Passenger vehicles (motor)	0	1	3	5	5
	Motor trucks	0	....	16	29	30
Total	Locomotive cranes	56	72	109	188	220
	Locomotives	25	34	51	59	66
	Railroad cars	....	....	439	620	534
	Horses and mules	175	144	180	182	190
	Passenger vehicles (horse)	26	22	9	1	0
	Passenger vehicles (motor)	0	24	64	100	119
	Motor trucks	0	....	325	523	484

During 1917 and 1918 orders were placed for motor vehicles and motor-truck trailers to be sent abroad as follows: Passenger cars, 343; motor trucks, 594; motorcycles, 237; motor-truck trailers, 211. At the time of the signing of the armistice a number of these orders remained unfilled; at other times diversions or cancellations were ordered owing to changed conditions; so that the actual shipments abroad were reduced to the following quantities: Passenger cars, 261; motor trucks, 375; motorcycles, 197; motor-truck trailers, 194. The approximate total cost of this equipment was $2,700,000.

NAVY YARD COMMUNICATION SYSTEMS.

The various Government-owned communication systems were extended and otherwise improved during the war period as circumstances required. While there was a very large increase in the business to be handled, there arose no necessity for any radical change in prewar methods, and the expansion was, therefore, handled in a routine way without difficulty. The operation of the systems and of the privately-owned lines required for use outside the navy yards and stations during the war was under the cognizance of the Director of Communications, under the Chief of Naval Operations, and the activities of the Bureau of Yards and Docks were limited to matters pertaining to the Government-owned physical property.

PUBLIC WORKS DATA BOOK.

The "Public Works Data Book," so called, is a loose-leaf binder publication, designed to contain current information in detail concerning the physical property of the Naval Establishment on shore of a permanent character. This includes land, buildings, dry docks, sea walls, piers, roads and pavements, railroad and other tracks, building ways for vessels, marine railways, storage plants, sewers,

Typical yard locomotive crane.

Twenty-five ton locomotive crane on elevated trestle for twin minesweeper construction, Navy Yard, Philadelphia, Pa.

Typical yard 5-ton locomotive crane.

Typical yard locomotive and dump-cars.

Typical yard 5-ton truck and trailer

Adaptation of yard truck and semi-trailer for boat haulage.

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pipe lines, telegraph and telephone lines, railroad and other tracks and equipment, power plants, radio towers, and similar property constituting the public works and public utilities of the Navy. Revision of the contents of this book is one of the duties of the Maintenance and Operating Division.

YARD MAPS.

The book of yard maps consists of a loose-leaf binder, measuring 16 by 21 inches, containing lithograph prints of the maps of navy yards and stations and of other important shore establishments. The maps are made annually and show the conditions existing on June 30 of each year.

CHAPTER XXIII.

EMERGENCY OFFICE BUILDINGS, POTOMAC PARK, WASHINGTON, D. C.

BEGINNINGS OF PROJECT.

The monumental State, War, and Navy Building adjacent to the White House long ago became inadequate to its requirements, and various bureaus of the War and Navy Departments had to seek office space elsewhere. Three years before the war a 9-story building was rented for naval bureaus and completely occupied by them. In this structure, near the corner of New York Avenue and Eighteenth Street, and known as the Navy Annex, the Bureau of Yards and Docks had quarters.

The threat of war caused a further overrunning of accommodations, and the actual declaration of hostilities soon produced unprecedented colonization by numerous Government agencies of all conceivable office spaces in the city. The expansion of the War Department was naturally the greatest of any, but the Navy's case was analogous. On July 1, 1917, this department was occupying space in nine different buildings, and was severely overcrowded in all.

The Bureau of Yards and Docks, for example, removed its headquarters from the Navy Annex to the American National Bank Building on July 28, 1917. By this move it increased its floor space from 8,300 to 28,600 square feet. Eight floors and the basement of the banking structure were occupied by it, but some of its most important offices were still housed in three other widely separated buildings.

Expedients for taking care of the continuous expansion of the Navy Department were carefully considered—rentals, commandeering of finished and unfinished structures, remodeling, and "emergency" construction. At one time during August, 1917, there was drawn up a detailed assignment of space for naval bureaus in the unfinished Arlington Building, which was set aside soon afterwards for the new Bureau of War Risk Insurance.

Then a scheme was formulated in the War Department which was to make one bite of two large cherries. This was nothing less than a proposal to shelter the whole overflow of the Navy Department and

all homeless agencies of the War Department in a monster block of temporary 3-story frame and pebble-dash buildings at Sixth and B Streets, to contain 800,000 square feet of net office area—the Henry Park project. The Navy was assigned one-third of this space, $2,000,000 was duly appropriated for the undertaking by Congress on October 6, 1917, construction began on October 11, and an engineer in the Bureau of Yards and Docks, under the direction of Commander A. L. Parsons, resumed his endless task of space assignment for the Navy. The entire group of buildings, possibly the largest of its particular kind extant, reached final completion in February, 1918; and long before that time the demands of both the departments made it certain that placing the Navy Department in Henry Park would be an ill-advised move. Fifty thousand square feet was the maximum space ever occupied in this group by naval bureaus.

Early in January it became clear that the Navy must shoulder its own burden. The work of devising adequate accommodations was delegated to the Bureau of Yards and Docks as the agency of "shore construction"—a violent departure from the orderly procedure of peace times wherein the Fine Arts Commission exerts a controlling influence under the immediate cognizance of Congress. Some demur was occasioned, but the war could not wait.

A bold solution presented itself. Efficiency demanded the location of the entire Navy Department under a single roof, and its activities and documents required quarters of fire-resistive construction. Speed in erection was essential, but an indefinite term of occupancy of the completed structure was contemplated as likely, while high unit costs were forbidden.

The use of reinforced concrete seemed to meet the foregoing conditions most fully. Previous experience with this material by the bureau under war conditions had been extensive and fortunate, and Commander Parsons was able to make out a very clear case for its use in the project under consideration. Investigation revealed that, while a stupendous structure would be required, it could be built of concrete with great rapidity and at a cost not unreasonably above that of an equivalent frame structure. The interest of a construction company of proved resources was enlisted, assuring the requisite labor and skill. Regular and speedy delivery of materials had already been placed within the Government's command. Presented with such data, the House Appropriations Committee was favorably impressed with the argument for concrete.

The next problem was the selection of a site, and informal surveys of the city were made afoot and by motor, the committee cooperating. Various locations were suggested, and it early developed that no structure so huge as the one contemplated could be usefully placed

Bird's-eye view of Navy and War Buildings, Potomac Park, Washington, D. C.

in Washington without dislocating some already formulated plan of civic development; so that the choice between evils became somewhat eclectic. The Ellipse was discussed and abandoned after preliminary plans had been drawn. A site south of the Tidal Basin was available and was carefully studied only to be given up on account of its inaccessibility. The Monument grounds seemed to offer a solution, and plans were elaborated for an L-shaped structure to the north and west of the Monument. But ground contours there necessitated grading at a high cost, and many valuable trees of long growth would be destroyed; furthermore, the project outgrew the available bounds during the very process of discussion.

Finally the tract of land in Potomac Park south of B Street and west of Seventeenth Street was discovered. The War Department by this time had submitted formal request that still more offices for its bureaus be built along with the new undertaking, practically doubling the space requirements and necessitating a ground area extending nearly 2,000 feet from Seventeenth to Twenty-first Streets and some 600 feet south from B Street. This tract could be easily served with transportation by the building of a loop of car track of moderate length. The objection to the site was the proposed building's interference with the plan of development of the Lincoln Memorial landscape, and this objection had simply to be waived for future adjustment in view of the instant exigency. The term of occupancy of these concrete buildings, whether "permanent" or "temporary," is to this day a moot point. It is commonly referred to as "indefinite," though the official title of the structures in the appropriation act authorizing them is "temporary buildings."

The project was broached before Congress in the Committee of the Whole House by Mr. Sherley, chairman of the Committee on Appropriations, on February 15, 1918. His remarks may be interpreted as a substitute for the customary committee hearings, the previous discussions between the committee and the bureau having been informal. Interesting questions were propounded by Members, to which Mr. Sherley was able to return satisfactory replies. The discussion continued at length on February 18 and was followed by the passage through the House of the urgent deficiency bill, including the appropriation for the project. This bill became law on March 28, 1918.

The appropriation for the proposed concrete buildings, $5,775,000, was figured on a basis of $3.31 per square foot, areas of 940,000 and 840,000 square feet being contemplated for the Navy and War Departments, respectively.

Meanwhile, upon authentic assurance that the deficiency bill would pass, the bureau had gone ahead on the project with all the speed possible. The Turner Construction Co. of New York, a concern

familiar with reinforced-concrete work on a maximum scale, assumed the general contract on February 25, 1918. They erected a construction office 220 feet long, 30 feet wide, and two stories in height at the corner of Nineteenth and B Streets, and installed their supervisory, clerical, and engineering forces without delay. Preparation of the site was prosecuted, a construction plant of novel design was installed, and large quantities of material began to be received. Prior to March 1, 1918, the advance force of the bureau took up quarters in the Turner construction office. This force consisted of the officer in charge of construction, Lieut. Commander O. A. Mechlin (C. E. C.), U. S. N. R. F., a dozen draftsmen, and a detachment of enlisted men serving in auxiliary capacities. Elaboration of plans on the part of the contractor and the bureau went forward hand in hand with the earlier stages of construction. Two subcontractors for heating and plumbing and electrical work built a joint office on the site during February.

The early history of the project may now be summarized, as follows:

(*a*) Preliminary studies, January and early February, 1918.
(*b*) Date of contract and beginning of work, February 25.
(*c*) Elaboration of plans, continuous, February–April.
(*d*) Granting of appropriation, March 28, 1918.

It is to be noted that the above steps occurred in practically the reverse order to the course of development of the majority of the bureau's projects as ordinarily executed.

As the work progressed, at really phenomenal speed, the bureau's supervisory force was augmented to cover the job. At the period of maximum activity, from May to August, 1917, this organization included no less than 10 officers of the Civil Engineer Corps, U. S. N. R. F., 120 enlisted men drawn principally from the Public Works Regiment at Great Lakes, acting as material checkers and inspectors, the architectural and drafting squad of 12 to 15 men, about 20 clerks, including yeomen, and an adequate "expediting force," whose duty it was to keep materials flowing to the job at high velocity through the exercise of freight priorities, commandeer orders, etc.

DESIGN OF BUILDINGS.

The group as constructed represents essentially a single operation. Its two halves, known as the Navy Building and Munitions Building, are connected by a covered bridge of the full width of a cross-corridor, spanning the 100-foot roadway separating them. Considered thus as an entity, the project affords a greater area of available floor space than any other office building up to that time constructed, with 1,800,000 square feet of floor (41 acres) as against 1,700,000 square

Perspective of Navy unit, emergency office buildings, Potomac Park, Washington, D. C.

feet in the 41-story Equitable Building in New York, its nearest contemporary rival.

The units are three stories in height, with a structural framework of reinforced concrete, gypsum-board and plaster partitions, steel sash, and brick curtain walls. The latter are omitted along the exposed front and side façades, where a two-storied window treatment is used, and the concrete surface finished with a white cement-and-sand mixture rubbed in by hand.

The plan of each building is simple, consisting of parallel wings 500 feet long and 60 feet wide connected at the front (north) along B Street by a so-called "headhouse" 60 feet in width. The Navy Department unit has nine such wings, the War Department eight; this is their only essential difference in plan or treatment. The wings are separated from one another by courts 40 feet wide, each of which is crossed by two covered gangways at the level of the second floor. The ground occupied, inclusive of courts, driveways, and the parking space at the rear is about 20 acres in area.

Typical floor plan of Navy unit, emergency office buildings, Potomac Park, Washington, D. C.

Speedy erection demanded that the structural design be of the simplest type, and the beam-and-girder system was selected. This treatment resulted in a scheme of uniform structural units throughout, all column spacing and distances between girders being similar without exception, and complicated connections of beams and girders at columns being precluded.

As will be seen in the accompanying illustrations the two buildings are identical in appearance, the front and side façades being divided by pilasters into bays.

Upper floors are of reinforced concrete, designed to support a live load of 75 pounds per square foot, and are finished with a wearing surface of concrete. They are $3\frac{1}{2}$ inches thick, with one-way reinforcement of $\frac{3}{8}$-inch rods spaced 6 inches, center to center. Columns are spaced 20 feet apart throughout; interior columns are 18 by 18 inches in section; wall columns $13\frac{1}{2}$ by 28 inches. The first story is 12 feet 6 inches in height, floor to floor, the second and third 12 feet each. Column reinforcement consists of four $1\frac{1}{8}$-inch rods.

Girders are 12 by 20 inches by 20 feet in span, reinforced with five 1⅛-inch rods, while beams are spaced 6 feet 8 inches, center to center, and have 3-rod reinforcement and a section of 8 by 14 inches.

No basement is provided, the ground floor resting on the mean level of the site. This site, which is part of the filled ground known as Potomac Park, alongside the Potomac River, is well adapted to requirements, a minimum of grading having been necessary. To conform to minor differences of level, wings were "stepped" in certain instances.

The staircases are all of reinforced concrete, and are particularly wide—these being the only means of travel from one floor to the other. Besides four main flights located in each headhouse, each wing is provided with two or three supplementary stairways properly situated.

In addition to the gypsum-board and plaster partitions generally used, partitions of a fire-resisting material are placed at intervals, dividing each floor into sections so as to localize any fire that might break out. All openings in these partitions have automatic fire doors, thus making each section an independent compartment, and the staircases are so placed that egress from one section may be had without passage through any of the others.

The use of steel sash insured rapidity of construction, large glazed areas affording ample natural lighting, and (where glazed with wire glass) a considerable factor of fire protection.

The corridor partitions have an unusually large glass area, which makes the corridors cheerful and pleasant on even the dullest days.

Plaster is used on the partitions and inside the curtain walls; ceilings (except that of the third story), beams, and columns reveal the structural concrete as the forms left it, giving the not disagreeable effect of heavy timber construction. Water-color paints of harmonious tints are used throughout the interior concrete and plaster surfaces. The roof structure is identical with the floors, except for necessary slopes. Pitch and gravel over 5-ply felt is the roofing material used. A suspended ceiling of gypsum board and plaster extends over the entire upper floor at a height of 11 feet.

CONSTRUCTION.

It was at first supposed that pile foundations would not be needed, but investigations made during the first two weeks of preliminary work showed this assumption to be in error. The area on which the buildings were to stand proved to overlie a portion of the old river bed. To reach solid ground through fill and soft material actually required piling varying from 20 to 52 feet in length. Where practicable, concrete piles (cast in place within predriven shells) were

used; but in a certain per cent of the cases the penetration necessary compelled the use of so-called "composite" piling, consisting of a wooden pile surmounted by one of concrete. The total number of piles driven was 5,048—the first one on March 25 and the last one on May 28. Piling follows the lines of the outside walls over practically the whole area. Occupation of the buildings, however, was delayed by this operation not more than 30 days beyond the period originally estimated. Four pile drivers were operated continuously by three shifts of workmen 24 hours a day, including Sundays.

Much credit is due the contractor for the skill with which his great resources and organization were applied to the peculiar difficulties of concrete placing on this job. The project was extraordinarily thin in distribution, requiring less than 2 cubic feet of concrete per square foot of ground covered. Nevertheless the bulk of concrete was vast, and it had to be placed with all possible speed.

A construction plant was devised which admirably met the conditions. A heavy trestle was built paralleling the entire length of the site (2,200 feet) at the rear, 17 feet in height, and having approaches from the street level with a gradient of 11.8 per cent. This trestle was designed to carry 5-ton motor trucks, which brought sand and gravel from near-by river dredgings, and cement in bags from a railroad siding adjacent. Eight storage units for this material were placed at intervals underneath the trestle, each provided with separate bins for 55 cubic yards of sand, 110 cubic yards of gravel, and a suitable supply of cement. The aggregate bins were covered by gratings of 4-by-12-inch planking, set on edge and spaced 4 inches apart. Over the trestle a fairly steady procession of trucks passed from east to west, dumping sand or gravel through the proper gratings or delivering sacked cement through chutes for storage as needed.

Midway of alternate courts of the buildings under erection were located the mixing plants, each connected with one of the storage units by a straight track of narrow gauge at right angles to the trestle and about 300 feet long. Upon these tracks ran small cars of the industrial type, having separate compartments for sand and gravel, and controlled by an endless rope from a motor at each mixing plant. Brought to a stop under the trestle, they were automatically loaded with sand and gravel in proper quantities from the bins, and cement being then thrown in on top they were ready for the return trip to the mixer.

Each mixing plant comprised a 1¼-yard mixer sunk below ground level, a 40-horsepower electric motor for its operation, and a tower hoist for the distribution of the mixture.

Concrete was delivered to place in two-wheeled buggies, operating at four levels from platforms adjoining the towers, no chuting being

employed at any stage. The capacity of each mixing and distributing unit, with 50 hands each, was 400 cubic yards per day, restrictions as to quantity of dry material having been eliminated by the system already described. Since each plant was entirely independent of the rest, the theoretical maximum capacity on the job was 3,200 cubic yards of concrete per 10-hour day, though practical conditions kept the recorded maximum down to 1,750 yards, equivalent to a section of the building 300 feet long.

The placing of the structural concrete was accomplished in 13½ weeks from April 5, 1917, an achievement which is thought to have established a record for this type of work. The weekly output was equivalent to a 780-foot section of the structure, while the total yardage of concrete employed on the job was 68,000. Concreting of the ground floor was a separate constructional operation and one of the last performed. This floor is of concrete 6 inches thick over a puddled and rolled fill of earth and cinders, with a wearing surface similar to that of the upper floors.

It is not to be supposed that the construction of these immense buildings proceeded by definitely separated steps. Such a thing would have necessitated sudden and complete replacements of large bodies of workmen as the character of the work changed. Rather the progress of the project was a development proceeding in general from east to west. Concreting overlapped pile driving and at last displaced it; roofing had been placed on the first wing before form work was complete on the last; bricklaying followed the advance of the concrete frame; partitions were being constructed on the upper floors before the ground floor had been laid.

ACCESSORY AND INCIDENTAL FEATURES.

As previously intimated, the interior finish of the buildings is, in general, far from elaborate; but some care was devoted to the architectural treatment of the two main entrances.

Both buildings have in the center of the headhouses large vestibules entered by nine double doors, giving free passageway under the most difficult conditions. Opening from the vestibules are the main staircase halls, of such dimensions as to admit of the transaction of preliminary business concerning identification and similar matters.

The vestibules and halls present a finished appearance, having plaster walls and ceilings with embellishments of columns, pilasters, and cornices. A durable floor is provided in these rooms, consisting of cement and small pebbles, the latter being treated so as to give a pleasing finished texture and color to the surface.

The floors are subdivided to meet the particular needs of the various bureaus, but so arranged that access may be conveniently

gained to any and all parts of the buildings. The office rooms are plain, well lighted, and of workable proportions.

The suite of rooms assigned to the Secretary of the Navy and his working force has an individual treatment, though of modest design and material. Ornamental plaster cornices decorate this suite, together with presentable fireplaces and mantels and cork-tile floors. A similar treatment was given to certain important offices in the War Department unit.

The buildings, being located at some distance from the center of the city, and consequently inconveniently situated as regards restaurants, have large and well-arranged cafeterias to accommodate the many clerks during the limited period allowed for luncheon. Occupying the third floor of an entire wing in each building, the cafeterias are of such size as to provide service for 1,300 patrons at one time without confusion or apparent haste. The most modern mechanical cooking devices are in use in the kitchens, which were planned from data gained through an investigation of the largest cafeterias in the country connected with industrial institutions.

The toilet facilities are carefully placed and equipped with a substantial standard grade of fixtures. These rooms are exceptionally well lighted and ventilated and are generous in size. The women's toilets have rest rooms adjacent, a necessary adjunct in a building of this character.

Numerous ice-water fountains are conveniently placed in the corridors. Protection from fire is furnished by the installation of a modern fire-alarm system and hose equipment.

Two elevators, electrically controlled and operated, are located in each building for the purpose of handling freight. No passenger elevators are provided, the height of the building not warranting their use.

A low-pressure vacuum-return steam system is used for heating the buildings, the live steam being furnished by a local power company. This steam is transmitted from the point of supply, a mile distant, to the buildings by means of underground steel piping, each length of pipe being welded to the next and expansion joints being inserted at regular intervals.

The telephone system of the Navy Building is controlled from a large exchange located in the center wing of the first floor, and provides a complete intercommunicating system in addition to the usual outside service.

This building also has its own post office, equipped and maintained as a branch of the city post office. It is complete in every detail and so arranged as to handle expeditiously the enormous amount of mail passing through the department each day.

Proper protection of floors of the two buildings was a problem which occasioned careful thought as the project developed. Disintegration of concrete wearing surfaces, no matter how finished, was considered an inevitable final outcome of intensive occupancy, with the consequent probability of irritating dust in the air of the rooms. Other familiar characteristics of concrete floors suggested that any covering used should be resilient and chill resistive, especially in consideration of the large proportion of women among the prospective occupants.

Linoleum was the material seemingly best adapted to conditions, and with the full approval of Congress the major area of the two buildings was thus provided. The fabric chosen was a linoleum three-sixteenths inch thick, of a good commercial grade and a solid brown color. It was not laid until some months after the completion of the buildings, a period being allowed for the curing of the concrete.

The contract for supplying and placing this linoleum was no small undertaking, involving as it did an outlay of some $325,000. A force of 75 men worked for five months, from January to May, 1919, laying the fabric. Even then, only 29 acres out of 41 were covered, corridors and certain special areas being left bare. The choice of linoleum in lieu of other floor treatment is considered to have justified itself in every respect, having contributed largely to health, comfort, and efficiency.

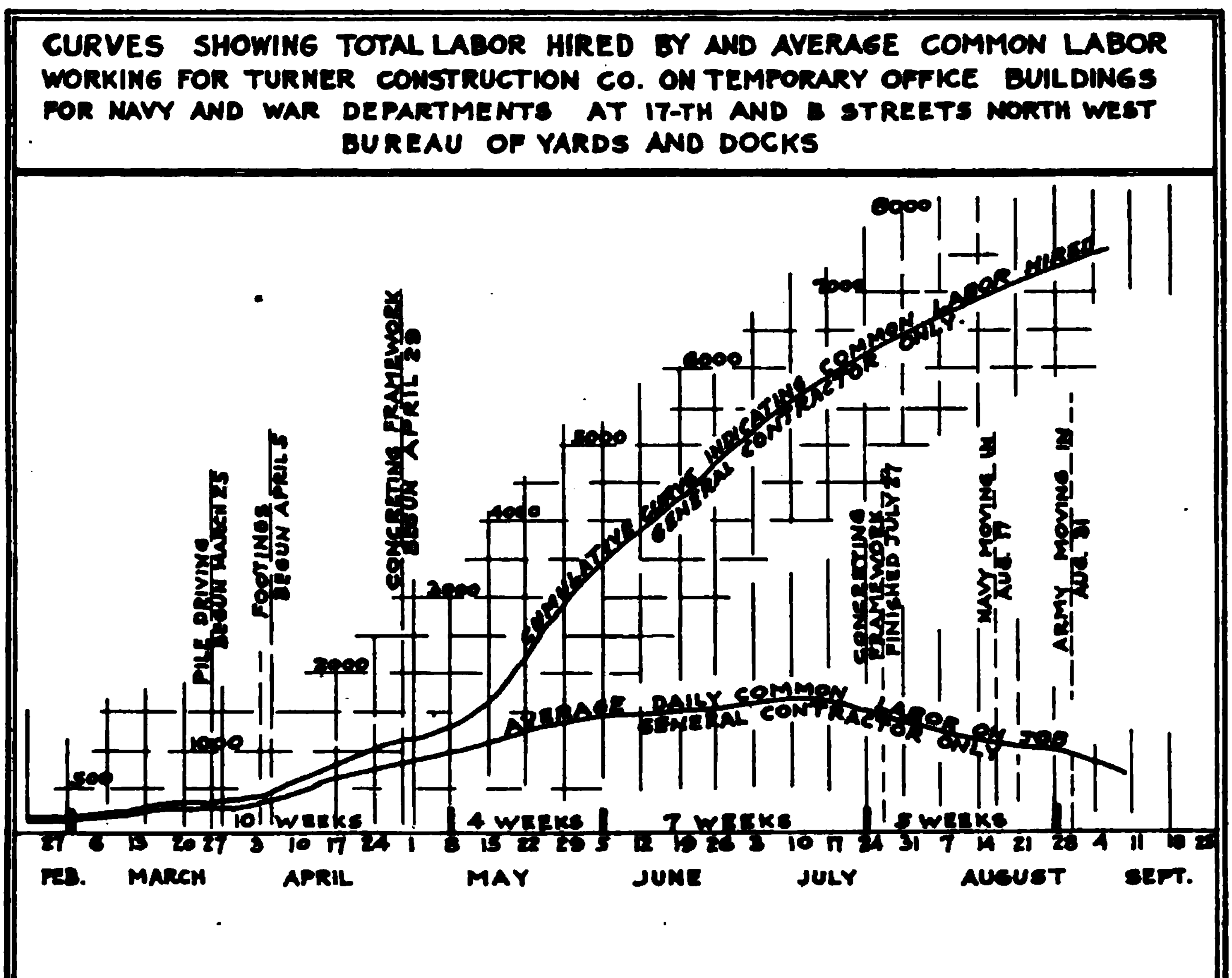
To accommodate the large number of automobiles previously parked in the neighboring streets, a macadamized space for the purpose is provided at the rear of the building. This space is large enough to accommodate 500 machines, and is inconspicuously inclosed by tall wire fencing. Gateways at various points, attended by guards, control the passage of the machines.

THE LABOR FACTOR.

The maximum construction force on the buildings, including both skilled and unskilled labor in the employ of the general contractor and all subcontractors, was approximately 3,400 men, of whom approximately 1,600 were carried as common labor. This maximum was maintained through June and July, 1918. Workmen of all the building trades were employed in numbers unequaled by any previous job of the kind in the District of Columbia. Speed was a primary consideration in the work, and its wide distribution made possible the effective employment of many large independent gangs.

The contractor brought to bear every worthy incentive on his workmen of all ranks to maintain a high standard of output. To this end inspirational and "welfare" activities of a variety adapted to

conditions were carried on throughout the life of the job. Graphic charts were exhibited showing the weekly progress of construction. Records of conspicuous gangs were posted and higher records encouraged. Frequent opportunities were afforded for the entire personnel to assemble in rallies and mass meetings at midday or in the evening. A patriotic spirit was fostered at such gatherings by means of addresses by persons of prominence, singing of popular airs, band music, and the like. Evening entertainments such as boxing bouts, pie-eating matches, and dancing competitions proved helpful in maintaining a degree of morale. An illustrated paper abounding in cartoons, portraits of noteworthy gangs and individuals, personal ref-



erences, and items of project news was issued weekly. An illustrator of proved ability was engaged to reside on the job and produce posters and other pictorial work for the stimulation of enthusiasm. A "job flag," displaying an eagle poised on a broom, was designed by him and flown during working shifts. The sale of war savings stamps was pushed with considerable publicity.

But economic conditions at the time were such as to offset a great volume of inspirational and welfare work. Common labor caused the greatest concern, beginning about the middle of May to develop a pronounced migratory tendency, which was simply a reflection of the workers' unrest affecting the entire country. Rates of pay for

unskilled labor on this job started at 30 cents an hour and increased rapidly to 44 cents in order to compete with the New York market. Railroad fare and expenses were paid for incoming workmen and return fare for the minority who continued at their tasks until completed.

Little difficulty was experienced in securing common labor up to the time the gang reached 1,000, and during the first ten weeks of the project, up to May 15, it was necessary to employ only 12 per cent more hands than were actually at work. On that date, owing to the increasing unrest, the ratio of men hired to men employed took a sudden jump, which is well illustrated in the accompanying diagram. During the life of the job 7,500 common laborers (principally Negro) were hired by the general contractor to recruit his labor gang, which never included more than 1,500 or 1,600 men at any one time. Keeping up the average force at this number for a period of seven weeks necessitated the hiring of 2,800 men, after 3,400 had already been sifted to establish the initial gang of 1,500.

As the work progressed, it was soon found necessary to build barracks and provide a commissary to take care of the men as they came in. Accommodations for nearly 1,200 men were provided, the barracks serving not so much as a permanent abode as for a transfer station pending the location of the laborers in other lodgings. These quarters were crowded to capacity, during the height of construction, with the transients and such others as chose to keep up a longer occupancy.

Needless to remark, the immense labor turnover in the face of expensive efforts to forestall it was a source of great anxiety. Every measure was adopted to prevent its interference with the scheduled rate of building. Such measures, while in general effective, were necessarily a factor in the great increase of costs above estimates.

COMPLETION; COST.

The dates on which important phases of the project were begun and completed are given in the following list:

Contract signed and work commenced on site	Feb. 25, 1918.
Appropriation granted	Mar. 28, 1918.
Pile foundation decided on	Mar. 9, 1918.
First pile driven	Mar. 25, 1918.
Last pile driven	May 28, 1918.
Concreting started (footings)	Apr. 5, 1918.
Concreting finished	July 27, 1918.
Moving in begun (Navy Department)	Aug. 17, 1918.
Moving in begun (Munitions Building)	Aug. 31, 1918.
Bureau of Yards and Docks moved in	October 1, 2, and 3, 1918.
Occupation complete	Early October, 1918.

It is thus seen that only 5½ months elapsed between the signing of the contract and the securing of beneficial occupancy of this record-breaking twin structure. Approximately 14,000 employees were transacting business within its walls at the date of the armistice.

Its cost has been defrayed from the appropriation of $5,775,000, made available on March 28, 1918, and from a later one of $1,490,000 made to cover deficiencies incurred. The said deficiency is attributable in large part to the unexpected labor turnover, the enforced use of pile foundations, and the employment of linoleum as a floor covering. The cost of the entire project, reckoned on a volume basis, amounts to approximately 29 cents per cubic foot.

The contract was let on the basis of cost plus a fixed fee, which enabled the contractor to prosecute his work almost as speedily as the necessities of war bureaus demanded.

MISCELLANEOUS DATA.

Navy Building has nine wings and headhouse.

Army Building has eight wings and headhouse.

Wings and headhouses are 60 feet wide.

Wings are 500 feet long from back to headhouse.

Length of Navy Building, over all, 862 feet.

Length of Army Building, over all, 782 feet.

Depth of both buildings, over all, 561 feet.

Total floor area inside of walls:

	Square feet.
Navy Building	940,000
Army Building	840,000
Total	1,780,000

Equals 41 acres.

Area occupied by halls, toilets, stairways, etc., is 22 per cent, or 390,000 square feet, leaving net office area of 1,390,000 square feet. Total cubic contents of both buildings is 25,000,000 cubic feet. The prism inclosing the buildings is 1,744 feet long by 561 feet wide, with a height of 40 feet.

The wings and headhouse placed end to end would make a 3-story building 60 feet wide and 1.9 miles long. The Navy and War Buildings together are three times as large in volume as the House Office Building. As for the State, War, and Navy Building, it would take six such structures to provide equal office space. To walk through these buildings and make an inspection of the radiators, a man would have to travel 25 miles; to make a circuit of the corridors only would require a tramp of 12 miles.

The Navy and War Buildings are constructed of enduring materials, and are on foundations of the most permanent character,

and, in respect to their arrangements for light and air for office purposes, are equal to if not better than any of the permanent buildings in Washington.

A bill of materials for the project, if drawn up in a single document, would have included the following items:

Steel reinforcing bars, 4,500 tons.

Eight and one-half acres of steel sash.

Twenty thousand separate window shades.

Roofing felt, 3,000,000 square feet.

Nails, 8 carloads; lumber, 314 carloads—7,500,000 feet; glass, 18 carloads; putty for same, 3 carloads.

Radiators, 3,200; heating piping, 27.4 miles; plumbing fixtures, 2,800.

Trenches, 14 miles.

Lighting fixtures, 15,000.

Outlet boxes and fittings, 50,000.

Push buttons, 5,000.

The project was executed under the general direction of Commander A. L. Parsons (C. E. C.), U. S. N., at that time assistant chief of the bureau. Construction proceeded under the resident supervision of Lieut. Commander O. A. Mechlin (C. E. C.), U. S. N. R. F., acting as public works officer. The architectural features of the design were developed by a committee of the bureau consisting of Lieut. Commander F. W. Southworth (C. E. C.), U. S. N. R. F., and Messrs. H. J. Briggs, George P. Hales, and Charles H. Stratton.

The general contractors were the Turner Construction Co., of New York.

CHAPTER XXIV.

HOUSING FOR THE NAVY BY THE BUREAU OF INDUSTRIAL HOUSING AND TRANSPORTATION, DEPARTMENT OF LABOR.

The shortage of housing which the United States Housing Corporation was created to meet as a war-time emergency was not a new thing arising wholly by reason of the war. The war simply aggravated a chronic, widespread, steadily growing trouble of peace times, which still persists. Emergency conditions arising out of the war merely discovered the situation in a new light by emphasizing the vital relation between housing and the employment of workingmen. Increased pay, together with patriotic sentiments, brought many highly skilled workers to the jobs, but neither of these motives could compensate for intolerable living conditions; and the labor turnover, due in large measure to insufficient and unsatisfactory housing, was so huge as to result in some cases in actual decreases in output in spite of higher wages.

It became clearly apparent in the summer of 1917 that the housing shortage had become something with which the Government must concern itself, and which must be handled as a war emergency, since it was a great and increasing menace to the speed and continuity of production of munitions of war. On May 16, 1918, after various investigations and reports by a subcommittee on labor of the Council of National Defense and by various other agencies, Congress authorized the President to expend $60,000,000 (which was raised to $100,000,000 on July 8, 1918) "for the purpose of providing housing, local transportation, and other general community utilities for such industrial workers as are engaged in arsenals and navy yards of the United States and industries connected with and essential to the national defense, and their families, * * * only during the continuation of the existing war." The President delegated this authority to the Secretary of Labor. By Executive order, confirmed in the act of June 4, 1918, the Bureau of Industrial Housing and Transportation was created in the Department of Labor. On July 25, 1918, the United States Housing Corporation, created as an executive agent of the Housing Bureau, was first authorized to

expend these funds for actual acquirement of land and for construction.

After that date all additional housing required for civilian employees of Navy shore establishments and of private plants performing Navy work, was provided by the United States Housing Corporation out of these funds appropriated by Congress. Prior to July 25, 1918, some little emergency housing had been built by the Navy out of emergency funds at its own disposal. Rear Admiral H. H. Rousseau, U. S. N., of the Civil Engineer Corps, acted as the representative of the Navy Department on housing matters with the United States Housing Corporation, with the title of associate director. Mr. Philip Hiss, a well-known architect of New York City, was employed by the bureau as special assistant in connection with this work, and he also rendered valuable service as consultant on architectural projects originating within the bureau.

Additional quarters from which the Navy has benefited were provided by the United States Housing Corporation at Bath, Me., Bridgeport, Conn., Bremerton, Wash., Charleston, W. Va., East Moline, Ill., Erie, Pa., Indianhead, Md., New London and Groton, Conn., Newport, R. I., Norfolk and Portsmouth, Va., Philadelphia, Pa., Portsmouth, N. H., Quincy, Mass., Vallejo, Calif., and Washington, D. C. Additional projects under contemplation were abandoned upon the signing of the armistice, November 11, 1918.

In addition to improving the housing situation, the United States Housing Corporation was responsible for the improvement of passenger transportation facilities, from which the Navy work benefited, at Bethlehem, Pa., Bridgeport, Conn., Norfolk, Portsmouth, and Newport News, Va., and Philadelphia, Pa.

The following projects are typical illustrations of the work done by the United States Housing Corporation in the construction of housing for the Navy Department. For a more comprehensive account of the various projects attention is invited to the United States Housing Corporation's Report on War Emergency Construction (G. P. O., 1919), in which all information concerning these developments is fully set forth.

BRIDGEPORT.

The largest project constructed by the United States Housing Corporation for the Navy Department was that at Bridgeport, Conn., where contracts for war munitions for the Army and Navy amounted to approximately $60,000,000. The housing shortage here was one of the first to come to general notice, being specially noted in the report of the committee on labor of the Council of National Defense, in 1917, long before there was any housing organization. Here

were found in aggravated form the objectionable conditions of overcrowding, high rents, and insanitary living, with the resulting waste and delay due to labor turnover. Some 15,000 workers were employed in the following local industrial plants on Navy contracts: Lake Torpedo Boat Co., building submarines; Remington Arms Co., ordnance; Crane Co., pipe fittings, etc.; and the American & British Manufacturing Co., ordnance. For the benefit of these employees the Housing Corporation constructed for the Navy housing in the amount of approximately $6,000,000, accommodating a total of 889 families. This housing consisted of 5 detached houses, 52 semidetached, row houses for 242 families, 73 detached 2-flat, 3 semidetached 2-flat, row 2-flat houses for 56 families, and apartments for 324 families. These houses ranged in size from three to six rooms with bath. There were five sites in various parts of the city.

The site near the plant of the Crane Co., known as the Crane tract, is also near many other plants in the west-central manufacturing district of Bridgeport. This site is particularly interesting from an architectural and artistic viewpoint on account of the fact that though the ground was almost level, with few trees, a surprisingly diversified and attractive general appearance has been obtained. This result was accomplished by the employment of an extremely irregular, picturesque, and accidental-seeming plan instead of the usual gridiron or the stilted curvilinear system of layout. The designers prepared block models of the building masses and studied their relations to each other from every point of view in three dimensions, a precaution of great value in getting such results as were here secured. These houses have an air of domesticity, a look of comfort, due to several causes. In the first place they are comparatively low—they seem to cling to the ground and to each other in neighborliness; they have a look of solidity, for their materials are of a permanent nature, being brick with slate roofs. They are pleasant to the eye, being of a soft red tone, and they appeal to good taste because of their simple long lines, and the delicate moldings of doorways and cornices and their general proportions. There is a distinct similarity in the houses, yet nowhere is the view of any row monotonous. The plan of the interiors is comfortable, consisting of four rooms and bath, and diversified in layout so as to suit the convenience of almost any small family. This project accommodates 257 families. It was ready for occupancy May 27, 1919, and completed September 1, 1919.

All of the houses built by the United States Housing Corporation in Bridgeport are of brick, which fact makes them especially worthy of future study with a view to determining their true value as a marketable real estate development.

HAMPTON ROADS.

The great advantage of Hampton Roads as a harbor and shipping point led to an enormous development of these facilities by the Government along various lines. The largest undertakings in this region were the additions to the plant and to the work of the United States navy yard at Norfolk, the naval operating base, and the ammunition depot at St. Julien's Creek, all for the Navy, and some large developments for the Army.

While the Navy had large contracts with the Newport News Shipbuilding & Dry Dock Co., which is located in this general region, it happened that this company was also performing a great amount of work for the United States Shipping Board Emergency Fleet Corporation, which latter corporation had its own special appropriation from Congress to relieve unsatisfactory housing conditions in the vicinity of private shipbuilding and other plants performing work for the Emergency Fleet Corporation. The existence of an arrangement between the Navy Department and the Emergency Fleet Corporation, whereby the latter undertook to provide additional housing in the neighborhood of Newport News, made it unnecessary for the Navy Department to request any assistance in this locality from the United States Housing Corporation.

Between May 1, 1917, and January 1, 1918, 20,000 people came into the Hampton Roads district—about 7,000 white and 3,000 colored workers, with equal numbers of dependents. By January, 1918, the housing shortage became very serious. At this time the various industries employed over 18,000, and the work in prospect called for at least 40,000. It was estimated that housing was needed for 26,400 men, and the estimated cost was $10,000,000. As the total operations of the Army and those of the Navy were of about the same size in this district, it was suggested that each pay one-half of this amount from its available funds. Ultimately, however, the Housing Corporation assumed responsibility for this project, out of the funds authorized for its use by Congress.

There were three sites chosen—Glenwood, near the site of the Jamestown Exposition, serving the Navy operating base and the Army operating base; Truxtun, for colored workers, just outside of Portsmouth, serving the navy yard; and Cradock, for white workers, south of Portsmouth, on Paradise Creek, also serving the navy yard. The Glenwood project was discontinued after the signing of the armistice.

At Truxtun the Housing Corporation built 198 detached houses and 26 semidetached houses, all of the same five-room type, with four different elevations, and some modification of porches to vary the design. There were also built four apartment houses. Alto-

gether provision was made for the accommodation of 254 families, with an expenditure of approximately $900,000. This project is well adapted for housing the colored families of the district.

The Cradock project was designed before the stringent rules of the War Industries Board went into effect and before the standard plans had been formulated, so that there was opportunity to make possible an unusually satisfactory architectural result. There were some 50 designs used, made up of about 40 different plans, of houses with five to seven rooms and bath. There were built 417 detached houses, 72 semidetached, 94 row one-family, and 9 apartments—housing for 771 families—and also 12 stores. This project was ready for occupancy on January 9, 1919, and was completed on August 15, 1919. The total approximate expenditures of the Housing Corporation on the enterprise were $5,345,739.28.

This development is situated on Paradise Creek, on low flat land, the average surface being only about 10 to 12 feet above mean low tide. The tidal variations of the water in Paradise Creek introduced a serious problem because, though the creek is very attractive at high tide, it is largely a mud flat at low tide. Only such filling has been done as would prevent the standing of any fresh water to breed mosquitoes. To provide access to the navy yard, the Housing Corporation built one bridge to connect Gillis Road with Gilmerton Boulevard, as extended. Also it was necessary to construct and properly pave the extension of Gilmerton Boulevard from the creek to the navy yard, both for the future traffic to and from Cradock and for the convenience of the Housing Corporation in the construction of the town; for the existing roads, poor enough at best, were turned into a slough in wet weather by heavy traffic.

The particular form of the street layout came about from the adaptation of plans to the topography and the determined sizes of lots and blocks. All the street names are those of men of note in the United States Navy. The names of places are arranged alphabetically in a circumference, beginning at Prospect Field and running contraclockwise; and the names of streets are arranged alphabetically from northwest to southeast. Most of the houses face northwest and southeast.

In addition to the stores the Housing Corporation arranged for a temporary schoolhouse and also for a hospital, the latter to serve not only Cradock itself but also accident cases from the navy yard. Sites for churches were provided, to be turned over to responsible church societies at a low or nominal charge.

The water supply was obtained from the existing water system in Portsmouth. This necessitated carrying a 16-inch water line from the Goodwin Street pumping station to the Belt Line Railroad

and a 12-inch main from this point to the housing development, the total length of 16-inch and 12-inch pipe aggregating slightly more than 2 miles and costing approximately $85,000. The distribution system within the development was made up of 12, 8, 6, and 4 inch mains, with sufficient hydrants to provide necessary fire protection. All services were metered.

A complete sewerage system was installed, including sanitary and storm-water sewers, and a sewage pumping station. The outfall sewer was arranged to discharge into deep water in the southern branch of the Elizabeth River.

An electric lighting system for streets and residences was installed, electricity being furnished by the Virginia Light & Power Co. at rates identical with those in force in the city of Portsmouth. This lighting system, by contract between the Housing Corporation and the Virginia Light & Power Co., the latter is to acquire at an appraised value which is to be made one year after the close of the war.

The labor question in constructing this development was a very serious one. Scouts were sent over the country as far as Missouri and Texas, and a maximum labor force of 3,000 was employed. Excellent meals at the commissary, a welfare building, and other inducements were provided; but the labor secured was largely of the floating type, and the turnover was approximately 30 per cent per month.

The method of erecting the buildings was to build the project in sections, by forming gangs of workmen to perform certain fixed kinds of work, and through repetition rendering them more efficient. Portable sawmills were erected on the site to take care of and cut all framing lumber and door and window frames. The amount of material required for each house was sorted and stacked in a pile near where it was to be used. All the framing for the houses was cut at the mill, so that all that had to be done was to assemble it in the field. The walls of the houses were erected on the ground and then lifted up into place.

Owing to the intense desire for speed, which seemed to permeate the very atmosphere, and the resultant tension under which everyone was living, it was necessary to provide a guard to protect the property and prevent quarrels. The guard consisted of 150 marines, and access to and egress from the property was had by means of a pass. The guards made periodic inspections of the negro labor camps, and after each inspection came away with a small arsenal of arms.

This Cradock development was the largest single project constructed by the Housing Corporation, and is one of the most successful from an architectural standpoint, on account of the ample size and the beauty of design of all the numerous types, which cause them to be suitable for the highest type of worker.

To provide quarters for the laborers in the vicinity of Norfolk, the Bureau of Yards and Docks built certain labor camps out of emergency funds. A camp with a capacity of 500 to 700 men was built outside the naval operating base; a camp for colored laborers, capacity about 300 men, at the navy yard; and another camp outside the navy yard for white laborers, capacity about 1,000 men. This last camp was next to a camp constructed by the Housing Corporation, having a capacity of 2,000 men.

PHILADELPHIA.

At the navy yard, Philadelphia, Pa., there was tremendous activity and an influx of new workers. At the east end of the yard was the new naval aircraft factory employing 1,400 men. At the west end, new dry docks, piers, and shipways for the construction and repair of the largest ships were under way, one ship to cost $19,000,000 being under construction. By the spring of 1918, 15,000 workers were expected, and there was an entire lack of houses for men with families within one hour and a half of the navy yard by trolley. The percentage of labor turnover at the navy yard was large and was complicated by the fact that the Hog Island, Cramps, and other shipyards near-by offered many inducements.

For the benefit of the navy yard employees, the Housing Corporation made plans for two sites. One of 36.5 acres lay along Oregon Avenue, and was 1½ miles north of the yard, all the land between being very low and requiring heavy filling. The other site comprised an area of 94 acres on Penrose Avenue, which project was discontinued upon the signing of the armistice.

At the Oregon Avenue site the Housing Corporation constructed 650 brick row houses at an expenditure of $3,693,636.29. These houses are grouped on blocks larger than the typical Philadelphia block, and the series of row houses in each block was made to group around a central open space, this space in each group serving and being developed as a neighborhood playground.

QUINCY.

At Quincy, a city of about 50,000 people, 7 miles southeast of Boston, are located the great Fore River shipyards of the Bethlehem Shipbuilding Corporation. Before the war the shipyards employed about 4,000 men. Navy Department and Shipping Board contracts increased this number nearly fourfold, producing a most serious housing shortage and entailing an enormous labor turnover. Overcrowding and the resulting bad sanitary conditions were most common. A portion of the work of the shipyard continued night and

day, being conducted on a three-shift basis, and in some of the boarding houses beds were used on a three-shift basis also.

The Housing Corporation, after a careful study of the situation, decided that the housing provided must be within walking distance of the yards on account of the congestion of street-car traffic and various transportation difficulties. Accordingly four sites were chosen, none being more than one-half mile from the yards. Housing was constructed for 424 families in the form of 90 detached houses, 109 detached two-flat, 57 semidetached, and 10 old houses repaired. At Cleverly Court there were built 21 dormitories for single men, accommodating 46 men each, a total of 966 men. The expenditure for this housing was approximately $3,272,698.73. Some of the houses were built of brick, others of shingle or clapboard; roofs were of slate or asphalt shingles, generally green. The houses are of colonial type, as is fitting, considering the surrounding district.

VALLEJO.

The Mare Island navy yard force was greatly augmented by reason of the war, and employees could find accommodation neither on Mare Island nor in the adjacent town of Vallejo. The nearest available site for civilian housing, not held at lot prices, was on the rather steeply sloping hillsides north of Vallejo, facing southwest across Mare Island Strait, near the end of the causeway connecting Vallejo with the navy yard. Two tracts were secured by the Housing Corporation, one of about 7 acres for dormitories and the other of about 110 acres for houses. Of the 110 acres only about half were developed, though all were planned. The site for houses is a steep hillside slope with a beautiful outlook toward the mountains of Marin County. The present development lies on the hillside facing Mare Island Strait. The whole site was open pasture land, with neither houses nor trees.

Approach to the site is by Wilson Avenue, along the shore. An unloading pier was built in front of the development, so that most of the materials might come by water, making a substantial difference in the cost of the work.

Provision was made in the plan for sites for two schools, a community hall, and small group of stores, but none of these have yet been built. There is also opportunity for other community groups, including churches, moving-picture halls, and stores. The main lines of the street system consist of the approach street, Wilson Avenue, along the water front, and the main arterial street, Daniels Avenue, leaving Wilson Avenue at a narrow angle to minimize gradient, and running between the two rounded hill summits to the northern boundary of the property. There are also two other lines leading

back from the shore, Sims Avenue, running on easy curves over and around the hill where the slopes are less steep, and a series of streets near the southern boundary of the property, climbing the steep hill in a series of zigzags to obtain possible gradients, and even then being in places as steep as 12 per cent. The rest of the streets run for the most part parallel to the hillsides. There were a number of instances where advantage was taken of the steep slopes and the considerable area betwen parallel streets to provide sites for groups of neighborhood garages, the buildings to be cut into the hillside. These have courts and approach drives to the near-by streets. The trend of most of the residential streets is east of south and west of north, and as they are arranged in tiers along the hillsides, houses facing them not only get morning and afternoon sun, but either the front or the rear rooms and porches command an inspiring view across the narrow strait, low-lying Mare Island, and the upper waters of San Francisco Bay to the mountains of Marin County and the summit of Mount Tamalpais only about 20 miles to the southwest.

Because of the somewhat isolated location of the project, it was necessary to consider it as an independent town-site development, for which original provision for all utilities had to be made. The permanency of the project as an adjunct of the navy yard being assured, the type of construction adopted was of a more durable character than that which might otherwise have been used. The side-hill location of the streets necessitated heavy grading, and the street paving demanded was of a type that would withstand moderately heavy traffic on fairly steep gradients, with adequate provision for heavy surface storm drainage.

The water supply of the project is the same as that furnished the navy yard, being pumped into the main which crosses Mare Island Strait from pumping plants some miles distant near Cordelia, as well as being fed from gravity reservoirs. The main has been tapped on the Vallejo side of the strait. Fire protection is assured by the construction of a 500,000-gallon storage reservoir on the highest point of the property at an elevation of 210 feet. Water is delivered to this storage reservoir from the supply mains by means of a duplicate pumping plant, each pumping unit having a delivery capacity of 600 gallons per minute under a maximum head of 250 feet. These pumps are controlled both by hand and by an automatic electric control apparatus. All water entering the project is metered after leaving the supply main through a Venturi meter equipped with a recording apparatus. Individual meters measure all water from the distributing mains to the consumers.

The entire tract was sewered in conformity with the most modern practice. The dormitory and house sections of the project each have separate outfall sewers extending into the tidal water of Mare Island Strait. The main outfall sewers were built sufficiently large to provide for any future extensions of the project which might be served by them.

A complete system of 4-inch and 6-inch gas mains was installed throughout the project for the distribution of low-pressure gas for heating and lighting. For the most part the water and gas pipes were carried in the same trenches.

The system of street lighting adopted was that of single-globe electroliers placed along the curbs at intervals determined partly by the curvature of the streets. The maximum spacing of standards was 250 feet, with an average spacing of 190 feet. Each standard was equipped with two 400-watt lamps. The wiring for the street lighting system was carried throughout in underground conduits laid in the sidewalk area between the curb and the walk. All electricity for house lighting and such uses was carried by means of aerial circuits upon pole lines placed at the rear of lot lines between the houses, with aerial drops from the poles to the houses. At no point is there an overhead wire crossing on any of the streets. Electric current is furnished from the central switchboard of the Mare Island navy yard to the transformer station of the project, which is located at the pumping station. Telephone service was provided, aerial cables being carried upon the poles at the rear of the lots with aerial drops to the houses. All telephone wires were carried across the streets in underground conduits. At the dormitory site both the street and house lighting circuits were carried in underground conduits.

An interesting planting scheme has been executed, which includes a considerable variety of street trees, many of them evergreens, not spaced regularly, however, but arranged quite informally in connection with groups of shrubbery and such hardy ground cover as Mesembrianthemum. Care was taken to use only such plants as when once established would thrive with a minimum amount of maintenance and no irrigation, and as would best withstand the strong winds, which are continuous through the summer months.

The Housing Corporation built in this project 83 detached houses, 12 semidetached, 30 semidetached 2-flat, and 10 dormitories, with cafeteria building, altogether accommodating 227 families and 400 single men, the approximate expenditure for this housing being $1,677,594.88. Certain lots, too steep for building, were set aside for neighborhood parks, and a generous playground of four acres was reserved for the proposed upper school. All of these open spaces are to be treated informally as to paths and planting. Through co-

operation with the Navy Department, in connection with periodical maintenance dredging in Mare Island Strait, it is hoped to fill in the flats immediately in front of the housing project, and this filled ground would eventually be turned into a park or water-front playground.

The roofs of the houses are all of wood shingles, which are left to weather naturally. All the trim was painted white, and the chimneys gray; the blinds were painted light green, and the walls of the houses of various colors. The project as a whole, because of its situation and topography, is one of the most picturesque of all the housing developments. The successful result is due to the correct conception of the kinds of houses suitable for the site, and to skillful adjustment of the streets and house locations to the steep and rolling hillside.

BREMERTON.

The following summary of housing activities in the vicinity of the Puget Sound navy yard (Bremerton, Wash.) is taken from the account of the civil engineer officer in charge of public works there at the time, Capt. L. E. Gregory:

By the month of March, 1918, the need of additional housing had become so apparent that the commandant of the yard strongly urged a liberal housing program, and in this work the public works officer necessarily became quite active in consultation relative to needs and ways and means. Being familiar with contractors in the locality, the sources of supply of materials, and local conditions generally, he was in close touch with all the various committees representing the Housing Corporation. The program finally adopted was the construction of a 350-room hotel on land owned by the Navy Department on the north side of Burwell Avenue, immediately opposite the navy yard foundry. An apartment house of 45 apartments was built on the corner of Seventh and Warren Streets. Both of the above-mentioned projects were made of substantial brick, with interiors of slow-burning, practically fireproof construction, and supplied with every modern convenience. There were also built 250 detached houses, scattered throughout the communities of Charleston and Bremerton, these being of wood construction of 3, 4, or 5 rooms, many of them with heating plants installed, and all with modern plumbing and lighting facilities. The justification for this construction was proved by the prompt occupancy of all these houses, the apartments, and the hotel to the fullest capacity, practically as soon as they were available. Subsequent to the war the Housing Corporation adopted the policy of selling all of the individual houses, and further justification of the program is indicated by the promptness with which the houses were all sold. It has been reliably stated that the Bremerton houses were sold more readily than those of any other project in the country. The hotel is being retained for operation under the direction of the commandant of the navy yard, inasmuch as it is located on Government property and connected directly with the navy yard by means of a tunnel under Burwell Avenue, making its location substantially as though it were within the physical limits of the yard.

OTHER PROJECTS.

At Indianhead, Md., and South Charleston, W. Va., as at Bremerton, the situation arose where the Housing Corporation constructed its projects on land owned by the Navy Department. When the question of disposal of the various housing projects came up, it was decided that it would be desirable for the Navy Department to take over the above projects also. This transfer, from the Department of Labor to the Navy Department, was effected by Executive order on June 29, 1920. The projects at Indianhead and South Charleston were placed under the cognizance of the Bureau of Ordnance, and the operation of the hotel at Bremerton was placed under the direction of the commandant of the yard, as stated. The hotel was operated during the year, up to the date of transfer, under the Department of Labor, in accordance with a contract originally entered into with the Navy Yard Hotel Association (Inc.), an organization of navy yard employees. This association afterwards assigned its lease to a second party. The lease, which was originally for one year, has since been extended for a term of three years.

All of the remaining projects constructed by the United States Housing Corporation for the Navy Department are being appraised as rapidly as possible, and sold by the Housing Corporation, an effort being made to sell the dwelling houses direct to prospective individual home owners who are citizens of the United States, and who desire the houses for their own occupancy.

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